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Airplane Stability and Control from a Designer's Point of View

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RECENTLY several papers have been published dealing with airplane stability and control problems from the pilot's point of view.[1,2,3] Although the airplane designer should not be expected to have any views on a subject so completely in the pilot's domain, he does have the responsibility of translating the pilot's requirements into concrete airplane proportions.

Many difficulties lie in the way of a complete understanding between the pilot and the designer. Among them are a lack of preciseness of definition of minimum requirements, a general lack of fundamentally sound numerical criteria, a lack of ability of the pilot to separate the variables as the designer does, and a lack of a comprehensive theory to guide the trend of design.

The natural result of the complexity of the stability problem has been that very simplified minimum requirements for stability have been evolved. These minimum requirements are known as the lateral stability, the directional stability, and the longitudinal stability. Although these terms are in general use, some doubt exists as to the desirability of the nomenclature used. This is particularly true of the term "lateral stability."

That no confusion regarding definition should exist after thirty years of building and flying airplanes would be a reasonable expectation. However, such confusion does exist in the definition of so fundamental a characteristic as lateral stability. This type of stability deals with the character of motion about the longitudinal and vertical airplane axes. However, experience has apparently shown that the airplane design characteristics that lead to lateral stability are undesirable from the pilot's point of view; that a laterally unstable airplane is easier to control than a stable one. This conclusion lead to the definition of new minimum requirements for lateral stability of controlled motion in which the rolling motion is arbitrarily separated from the yawing motion.

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Minimum Requirements

However, it is difficult to find anywhere an explicit statement of what "lateral stability" is. Confronted with this situation, the designer must make his own guess as to what is meant by lateral stability. Reference to standard nomenclature as given by the National Advisory Committee for Aeronautics provides very little help. The definition of lateral stability[4] as given by the N.A.C.A. is:

> "Stability with reference to disturbances about the longitudinal axis, *i.e.*, disturbances involving rolling or side-slipping. The term Lateral Stability is sometimes used to include both directional and lateral stability, since these cannot be entirely separated in flight."

What is this supposed to mean to the airplane designer? Does it mean merely that the rolling moment due to sideslip must be a restoring moment, or that the lateral motion must actually be stable? The usual interpretation appears to be that the rolling moment due to sideslip shall be a restoring moment, and the reference to rolling is merely meant to indicate that a rolling disturbance eventually causes a sideslip. According to this interpretation, the statement in the last sentence is incorrect, because the pilot can use the rudder to eliminate the effect of the yawing moment due to sideslip.

The airworthiness requirements of the Civil Aeronautics Authority also offer the designer very little aid

in deciding what lateral stability is supposed to be.[5] In the Civil Air Regulations the statement, that the airplane shall be laterally stable, is made. However, which brand of lateral stability is meant? A clue to the C.A.A. definition might be obtained from another publication.[6] This bulletin, which was written to instruct pilots about airplanes, states that the test for lateral stability is as follows:

> "With the rudder held in neutral, the airplane is rolled about its longitudinal axis to a fairly pronounced angle and the control stick immediately released. A sideslip will result and if the airplane recovers from the tilted position to an attitude of flight which is level laterally it is laterally stable."

All that can be said about this definition is that pilots are going to be very disappointed if they expect to find, among airplanes certified as airworthy by the C.A.A., many that are laterally stable, according to this definition.

Before we can expect to make much progress in raising the general level of flying characteristics, such variations of definition should be eliminated. If pilots agree that the direction of the rolling moment due to sideslip is a satisfactory minimum requirement for the characteristics in roll, it would be very much simpler and less confusing if the minimum lateral requirement was written in exactly those terms.

Much less confusion exists in dealing with the moment variation about the vertical axis. This factor is generally known as the "directional stability," and to the designer merely amounts to the yawing moment due to sideslip. However, there may be some who believe that the term "directional stability" means what it says. Unfortunately, the reverse is true, for the greater the "directional stability" the more directionally unstable the uncontrolled motion of the airplane becomes. The possibility of a misunderstanding would be eliminated in this case if the terminology were changed from "directional stability" to yawing moment due to sideslip.

In the case of longitudinal stability there appears to be no difference of opinion between the pilot and the designer as to the dividing line between stability and instability. The minimum requirement here is that slope of the pitching moment curve shall have the correct sign, which in most cases is sufficient evidence that the longitudinal motion will not be a divergence.

However, the necessary condition for the absence of a divergence is that the coefficient E of the familiar quartic obtained in the solution of longitudinal motion should be positive. In terms of the airplane design characteristics the coefficient E for level flight is

$$E = \mu C_L \left(- \frac{2C_L}{b} \frac{dC_m}{d\alpha} + m_u \frac{dC_L}{d\alpha} \right)$$

The only difference between the designer's and the pilot's minimum requirement for static longitudinal stability is that the former considers only the first term in the bracket while the latter cannot readily separate speed from angle effects in flight. Although the designer usually provides enough margin in the first term to allow for the generally unknown effects of the second term, cases have occurred in practice in which airplanes have become statically unstable after structural changes that stiffened the stabilizer, or after changes in the static balance of the elevator that moved its center of gravity forward.

Moreover, the designer's margin in the slope of the pitching moment curve slope must also be sufficient to overcome the slipstream effects in the m_u term. This slipstream effect tends to make the airplane statically unstable when the tail is carrying a down load.

Although the pilot and the designer have practically the same minimum requirement for static longitudinal stability, it is difficult to see how the designer's measure of the degree of longitudinal stability can mean much to the pilot. As is well known, the designer not only uses the direction of the slope of the pitching moment curve as a minimum requirement but also uses its magnitude as a measure or criterion of stability. He assumes that if the slope is made twice as steep, the static longitudinal stability is doubled.

The pilot, however, can only indirectly notice the effect of the size of the slope of the pitching moment curve. It is difficult to determine whether he uses the rate of change of elevator angle with angle of attack, the rate of change of stick force with angle of attack, or the rapidity with which the airplane returns to equilibrium, as his measure of the degree of longitudinal stability.

Unfortunately, there is no direct connection between any of the possibilities named and the slope of the pitching moment curve. For instance, in any well designed airplane the elevator control will be in its most rearward position when the airplane is flying at its maximum angle of attack with the center of gravity in its most forward position. This should be true whether the elevator angle required to maintain that angle of attack is five degrees or thirty degrees. Consequently if the slope of the pitching moment curve were doubled, the variation of the position of the pilot's control with angle of attack would be unchanged. Consequently there is no correlation between the designer's criterion of the slope of the pitching moment curve and the slope of the stick position curve.

The same can be said for the variation of stick force with angle of attack. Suppose in a given airplane the slope of the elevator hinge moment curve with elevator angle were doubled without changing the elevator effectiveness. The slope of the stick force curve with the angle of attack would then also be doubled. Would the airplane then be twice as stable? According to the designer, the static stability would not have changed because the slope of the pitching moment would not be

affected by the change of elevator hinge moment. However, to the pilot the slope of the stick force curve would be the same as though the center of gravity had been moved forward to double the slope of the pitching moment curve. He cannot distinguish between the two changes by the slope of the stick force curve.

Despite popular belief, an increase of the slope of the pitching moment curve does not in general increase the rate at which the airplane will return to equilibrium after a displacement. An examination of Fig. 1, which is a plot of the variation of the period of longitudinal motion with the design parameter $\mu \frac{dC_m}{d\alpha} \Big/ \frac{5}{4}\left(\frac{dC_L}{d\alpha}\right)' \frac{S'}{S}$ shows that the period varies with that parameter only at small values. Practically all airplanes that meet the

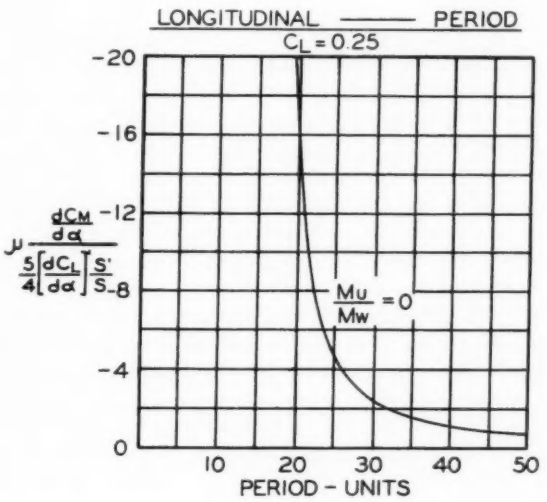

FIG. 1.

minimum requirement for static stability are in the range in which the period is independent for the slope of the pitching moment curve. This conclusion is checked by flight tests in which the periods of several airplanes were measured and found to be a function of velocity only.[7]

The conclusion appears to be that the direction of the designer's slope of the pitching moment curve is a satisfactory minimum requirement for longitudinal stability, but that it is worthless as a criterion of measure of longitudinal stability. The suspicion is that the designer tends to use a large slope of the pitching moment curve because he feels that stability is a fine thing to have, and then uses complicated elevator balances that usually reduce the maximum elevator effectiveness, in order to reduce the stick forces caused by the large slope of the pitching moment curve. The final result is the same to the pilot as though the designer had used the minimum possible value of the slope of the pitching moment curve in the first place.

Design Requirements for Controlled Motion

The meeting of the three minimum requirements of rolling moment due to sideslip, yawing moment due to sideslip, and static longitudinal stability by no means insures that the flying characteristics of the resulting airplane will be satisfactory to the pilot. Unfortunately, within the framework of the minimum requirements, all kinds of flying characteristics are possible.

Since an airplane is not expected to fly by itself, the stability that really matters is the stability of controlled motion, in which the pilot or automatic pilot move the control surfaces in accordance with a function of the displacement of the airplane. The controlled motion must be considered because certain modes of the airplane motion are inherently poorly damped, and the controls must be used to damp out those motions.

Under these conditions stability characteristics that tend to complement the pilot in flying the airplane rather than those that would allow the airplane to fly by itself have been evolved by experience. The idea that the easiest airplane to fly is one that will fly itself was proven false many years ago.

At the present time there is little information as to how a pilot moves the controls when he flies an airplane; as to what extent his control motion is a function of airplane displacement, angular velocity, or angular acceleration. Moreover, there is no information about the time lag between a disturbance and the control application by an average pilot.

Experience has shown, however, that all poorly damped natural motions are not equally important in controlled motion. The natural damping of the longitudinal oscillation appears to be entirely unimportant to the pilot, while on the other hand, a poorly damped lateral oscillation is likely to remain poorly damped in spite of the pilot or automatic pilot. There is probably no worse flying characteristic at cruising speed than a lateral oscillation that cannot be damped by use of the controls. The designer's problem is to proportion the airplane so that difficulty with a lateral oscillation will not exist.

A recent study[8] of the controlled motion of an airplane, in which the motion was studied with the aid of the M.I.T. Differential Analyzer, gives an explanation as to why a longitudinal oscillation is easily damped by the pilot and why a lateral oscillation often is difficult or impossible to damp.

As is well known, longitudinal motion usually consists of two oscillations, a short period rapidly damped oscillation and a poorly damped long-period oscillation. The action of the pilot's control is to redistribute the damping in the system so that the damping of the long-period oscillation is increased at the expense of that of the short-period oscillation. This effect is shown in Fig. 2. Moreover, the analysis further shows that this situation exists in spite of the pilot's lag in applying the control.

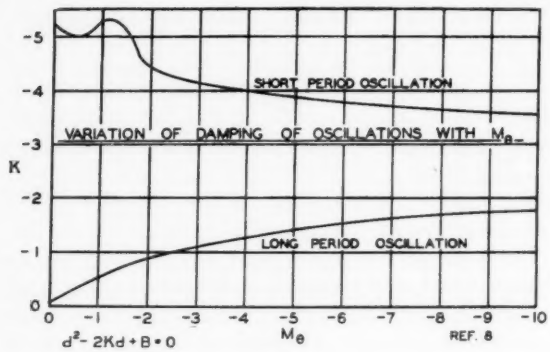

FIG. 2.

Consequently, a lack of damping of the longitudinal oscillation is usually unnoticed by the pilot, and the result is that any pilot can satisfactorily fly anything that looks like an airplane. Apparently, the only reason for worrying about the undamped longitudinal oscillation is to meet C.A.A. requirement.[5]

However, the same is not true of the lateral oscillations. When the controls are used, the lateral motion consists of two oscillations and a rapid convergence. The result of the aileron motion is to divert damping from the rapid convergence to the two oscillations. However, the ability of the ailerons to carry out this transfer of damping is controlled by the size of the yawing moment due to sideslip, that is, by the size of the vertical tail. Fig. 3, which is a plot of the variation of azimuth after a rolling disturbance, shows that the oscillation becomes very poorly damped when the yawing moment due to sideslip approaches zero. This

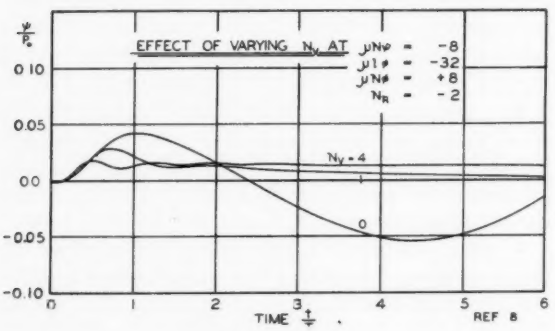

FIG. 3.

effect is well known in practice, and many airplanes have been improved in this respect by increases of vertical tail size. In addition, Fig. 4 shows that the possibility of damping this oscillation becomes worse as the dihedral angle of the wings is increased.

The second lateral oscillation appears to depend on the effective damping of yaw of the airplane for the major part of its damping. If the pilot lags behind the airplane motion in applying the rudder, the effect of the control lag is the same as though the airplane damping of yaw had been reduced. For instance, as shown in reference 8 the effective damping of yaw may be written as:

$$n_r' = n_r - n_\psi \frac{Vt}{b}$$

where n_r is the damping of yaw of the airplane,

V = speed in ft. per sec.,

n_ψ = rudder moment for a unit airplane displacement in yaw,

t = pilot's time lag in seconds,

b = length used in determining coefficients.

Since the period of this oscillation is usually short, of the order of from 2 to 4 seconds, the possibility of pilot lag is large. Consequently the designer must increase the damping of yaw to allow for the pilot's lag. Fig. 5 shows the effect of the reduction of damping of yaw on the motion.

This finding may explain the action of the automatic pilot in certain large transport airplanes. In the case of the automatic pilot the control motion is a function of airplane displacement and consequently the control motion will always lag behind the airplane motion. In these airplanes it was found by trial that the rolling and yawing oscillation was not well damped by the automatic pilot unless the rudder control response was well throttled, in which case most of the controlling was done by the ailerons. A mathematical analysis indicates that the lag in the aileron control system can be from two to three times as great as the lag in the rudder control system before the effective

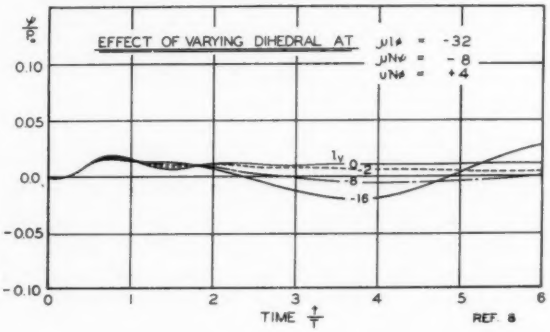

FIG. 4.

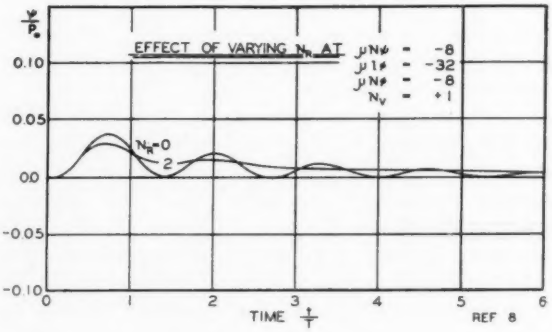

FIG. 5.

airplane damping is reduced to zero. In other words, the ratio of damping moment to control moment is from two to three times as great in the rolling direction as it is in the yawing direction.

That the trend of design has been in the direction of increasing vertical tail sizes cannot be denied. Fig. 6 shows the rapid increase of vertical tail volume coefficient in recent years. Although fuselage shapes have

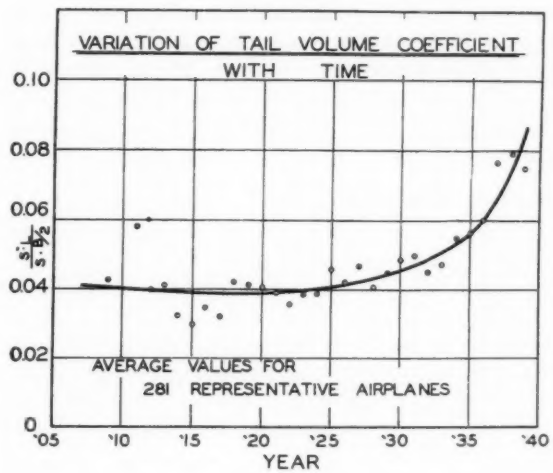

FIG. 6.

become more unstable, it is unlikely that the effect of the fuselage yawing moment alone can account for the trend in vertical tail size. It appears reasonable to assume that this design change is the result of experience with controlled motion, and that trial and error indicated that an improvement in the damping of controlled airplane motion resulted from an increase of tail size.

Another controlled motion difficulty that is not usually taken care of by the designer is the one concerning control sensitivity. The sensitivity is here defined as the ratio of airplane motion to control motion, that is, a sensitive airplane is one in which a small rate of control motion produces a large rate of airplane motion.

For geometrically similar airplanes the sensitivity increases as the wing loading is increased and as the size of the airplane is reduced. Difficulty is therefore to be expected with the elevator control sensitivity of small, high-speed airplanes, and the maneuver most affected by elevator control sensitivity is the often performed one of landing.

In longitudinally controlled motion the pilot's control of the flight-path angle is indirect; he can only control the attitude of the airplane relative to the horizon and learns by experience the change of flight-path angle that can be expected from a given change of attitude. However, in small, high-speed airplanes only extremely small rates of control motion are required to affect the necessary flight-path direction changes during a landing. In addition, this situation is often aggravated by airplane lateral characteristics that require a considerable margin of gliding speed over stalling speed.

The designer's position here is somewhat different than in the case of controlled lateral motion for by careful selection pilots can be found who are capable of controlling a sensitive airplane. Consequently designers have not been forced to find methods of reducing the sensitivity of such airplanes as they are forced to find methods of improving the pilot's control of lateral oscillations.

However, as far as the designer is concerned, the resulting sensitivity is purely accidental; it is not the result of a desire to meet some specific requirement. Moreover, it is unlikely that any useful performance feature is improved by a high longitudinal control sensitivity.

A study[9] shows that longitudinal control sensitivity may be reduced in an airplane of fixed size and wing loading by obtaining the necessary slope of the pitching moment curve by use of a more rearward location of the center of gravity with a correspondingly larger horizontal tail. This decrease of control sensitivity can be obtained without a reduction of controllability at the stall.

If the procedure of designing the airplane to meet the requirements of controlled motion is used, the airplane will invariably be spirally unstable. This divergence apparently makes very little difference to the pilot as long as his aileron and rudder controls are sufficiently powerful to make the controlled motion stable.

It has been shown[10,11] that the necessary condition for a spirally controlled motion is

$$(L/N)_{controls} > (L/N)_{sideslip}$$

where $(L/N)_{controls}$ is the ratio of rolling moment to adverse yawing moment of the controls, and $(L/N)_{sideslip}$ is the ratio of airplane rolling to yawing moment due to sideslip.

At the stalling angle, a more rapid spiral divergence is likely to occur. This is particularly true of airplanes in which wing air flow separation occurs at the wing-tip. In the power-on condition tip-stalling is likely to occur on most airplanes due to the action of the slip-stream in preventing flow separation over the wing center-section, and its action in increasing the elevator control moment.

The rapid lateral divergence caused by flow separation at the wing-tip is usually attributed to a loss of damping of rolling velocity. However, an analysis[12] indicates that the rapid divergence is caused by the yawing moment due to rolling. This moment, which normally acts to move the down-going wing-tip forward, reverses its direction after separation.

To the pilot, the fact that the motion is caused by a yawing moment rather than a rolling moment is only

of academic interest. To the designer, however, the fact is of considerable importance for to correct the direction of the damping of roll he can only take steps to avoid separation, while to retard the effect of the adverse yawing moment due to rolling he can increase the yawing moment due to sideslip and the yawing moment due to yawing velocity.

Concluding Remarks

The chief conflict of airplane design requirements does not appear to be between various types of controlled motion, but between the requirements of the stability of controlled and uncontrolled motion. Reference to Table 1, which indicates desirable trends of

Table 1

Summary of Desirable Design Trends for Various Flight Conditions

Lateral

Condition	Tail Size	Length / Span	Dihedral
Uncontrolled motion	Small	Large	Large
Controlled motion	Large	Large	Small
Aileron controllability	Large	Large	Small
Divergence at stall	Large	Large	Indifferent

Longitudinal

Condition	Center of Gravity	Tail Size	Tail Length / Wing Chord
Uncontrolled motion	Rear	Large	Large
Controlled motion	Indifferent	Indifferent	Indifferent
Control sensitivity	Rear	Large	Large
Change of trim with power	Rear	Large	Indifferent
Dive after stall	Rear	Large	Large

vertical tail size, tail length to wing-span ratio, and dihedral angle for lateral characteristics, and center of gravity, horizontal tail size, and tail-length to wing-chord ratio for longitudinal characteristics, enables the designer to draw the following conclusions:

Lateral Requirements

(1) From all points of view a large tail-length to wing-span ratio is desirable. This can hardly be considered a new discovery, since experience has long shown that airplane lateral characteristics improve as the tail length is increased. However, the designer's minimum requirements take no account of this factor, since an airplane can be made "directionally stable" in spite of a very poor tail-length to wing-span ratio.

(2) All of the requirements for satisfactory controlled motion indicate the desirability of a large vertical tail. The only conflict is with the requirement for spiral stability of uncontrolled motion, which indicates the need for a small vertical tail.

(3) A minimum of dihedral angle is indicated for all cases except that of uncontrolled spiral motion. Except for the case of aileron controllability the use of a larger dihedral, than the minimum required for the proper direction of the rolling moment due to sideslip, is not as harmful to the controlled motion as is the use of a small vertical tail.

Longitudinal Requirements

(1) In the cases in which the center of gravity has any effect, it appears to be desirable to meet the minimum requirement of the slope of the pitching moment curve with the center of gravity as far back on the wing-chord as possible. Naturally as the center of gravity is moved back, a larger tail size or a larger tail-length to wing-chord ratio must be used. The maximum rearward location of the center of gravity appears to be limited only by structural and performance considerations.

Research Suggestions

Since the controlled motion of an airplane is a combination of airplane and pilot characteristics, it is necessary to know something about both airplane and pilot characteristics before a satisfactory job of airplane design can be done. Regardless of how little the designer is considered to know about satisfying the requirements for desirable airplane flying characteristics, he knows even less about the pilot's contribution to the combination.

Research in the direction of determining the pilot's control motion relative to the motion of an airplane while flying in rough air would be most helpful. In addition, data concerning the average pilot's control application lag as affected by the period of the motion, the control force, and the moment of inertia of the control system, should be determined.

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Predetermination of Aircraft Engine Cooling Requirements for Specific Flight Conditions

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Introduction

FOR the installation of air-cooled aircraft engines, the design of cooling passages and cowlings follows, in general, a rational procedure, the principles of which are now fairly well understood.[1,2] The installation designer so proportions the resistance of his air entrance and exit passages to the resistance of the cooling passages of the engine itself that when his particular assumed value of dynamic head is applied across all three resistances in series, a suitable pressure drop across the engine cooling passages results. It has become quite important to achieve the right design of cooling system, for if the value of baffle pressure drop thus obtained is too low, insufficient cooling results and the installation must be revised. On the other hand, if the baffle pressure drop is substantially greater than necessary, the power consumed in forcing the cooling air through the system becomes excessive and some high speed airplane performance is thereby sacrificed. Also, if an adjustable cowl skirt is contemplated, the designer is anxious to so proportion it that the position of the skirt giving lowest external drag corresponds with the high performance cooling requirements.

For the past several years, the engine manufacturer has provided the designer with the equivalent orifice area of the engine baffle passages of his various models, which have been established by flow testing; and to facilitate the designer's calculations, direct reading charts relating cowl exit gap size to baffle pressure drop and cooling drag for any indicated air speed and altitude have been provided. Such a chart is illustrated in Fig. 1. A brief inspection of it will illustrate the wide variation in exit gap size required for maintaining a given baffle pressure drop at various air speeds, and also the severe cost in drag which results if an exit gap size excessive for the speed is selected.

Until recently, however, one link in the chain of rational cooling system design procedure has been missing, namely, a quantitative readily workable correlation of the principal variables influencing engine cooling performance under stabilized conditions. This is required so that the airplane designer may select the "suitable" baffle pressure drop which he must provide under his assumed conditions of allowable maximum cylinder temperature, brake horsepower, r.p.m., specific fuel consumption, pressure altitude, and prevailing air temperature. Such a correlation, in direct reading chart form for the airplane designer's convenience, is explained herein, and some important relations which become evident from its application to specific assumed conditions are briefly discussed.

Derivation of Chart

The correlation chart is based on results of single and multi-cylinder engine tests conducted on dynamometer stands at numerous times since 1934[3] to isolate the effects of the several cooling variables individually. This research was followed by a statistical and graphical compilation of about 100 dynamometer test stand records of multi-cylinder engines, corrected to a common basis of external cooling conditions by virtue of the results of the above investigations of the separate variables.

The cylinder temperatures chosen as the criterion of cooling performance for this study were the average and hottest rear spark plug gasket temperatures as measured by iron-constantan thermocouples. It was

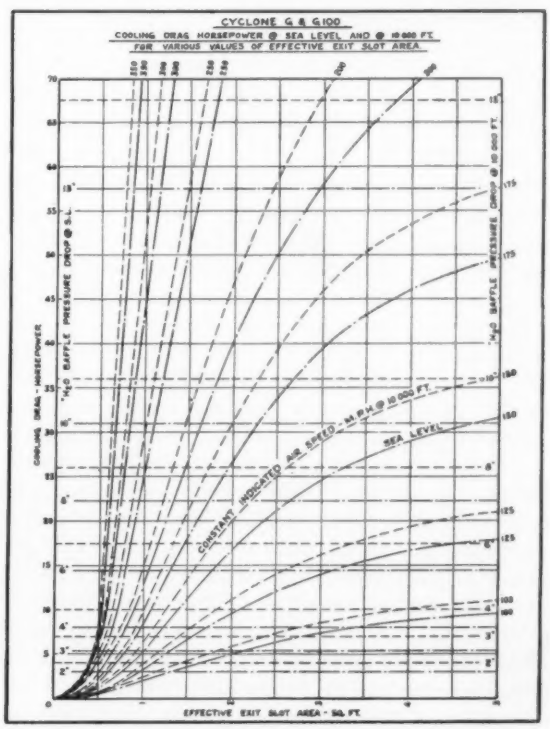
CYCLONE G & G100
COOLING DRAG HORSEPOWER @ SEA LEVEL AND @ 10 000 FT.
FOR VARIOUS VALUES OF EFFECTIVE EXIT SLOT AREA
SEA LEVEL
CONSTANT INDICATED AIR SPEED - M.P.H. @ 10 000 FT.
EFFECTIVE EXIT SLOT AREA - SQ. FT.

FIG. 1.

Presented at the Power Plants Session, Eighth Annual Meeting, I.Ae.S., New York, January 24, 1940.

necessary to make the correlation with respect to this thermocouple reading because of the latter's practically universal use as a criterion for Wright engine installation approval and airplane acceptance tests. While the use of the average of rear thermocouple readings for all cylinders on an engine should in each case be more reliable than use of the one hottest thermocouple, the large amount of multi-cylinder test data studied made the latter criterion almost equally reliable, and this is, furthermore, the temperature in which the airplane designer is interested. Hence, this "maximum rear head temperature" was chosen as the cylinder temperature criterion for the cooling variable correlation chart.

It is to be expected that variation in rate of heat transfer through the cylinder wall from the combustion chamber to the cooling air with variation of internal and external operating conditions should be related in some consistent and observable manner to the temperature difference between cylinder body (measured as above defined) and entering cooling air temperature. The data from the tests isolating the separate operating variables indicates that the relations between this temperature difference and the individual variables approximate exponential functions. Thus, if the isolated variable under consideration be plotted against the value of temperature difference obtained, the points (within the range of values of interest) fall approximately along a straight line on logarithmic graph paper, and the slope of this line is the exponent governing the relationship we are seeking. It was thus possible to plot all the research data obtained for each of the separate variables in this manner and to select a representative slope or exponent relating temperature difference to indicated horsepower, indicated specific fuel consumption, baffle pressure drop, and mass flow of cooling air.

An additional relation is important, namely, the variation of cylinder temperature with change in cooling air temperature. This correlation is based on the relation that a given rise in cooling air temperature is accompanied by an equal rise in rear spark plug gasket temperature. There has been a good deal of misunderstanding about this particular relation, despite the fact that two independent investigators[3,4] obtained data in 1935 which, they mutually agreed, correlated quite well. It appears worthwhile to clear up this point. One investigator, as he increased his air temperature passing over the single cylinder engine equipped with numerous thermocouples, maintained a constant mass flow of air and found that the rise in rear gasket thermocouple temperature was approximately 0.8 of the rise in cooling air temperature. However, to maintain mass flow constant it is necessary to increase the baffle pressure drop substantially with the increasing absolute air temperature, which is not representative of the condition of interest for this correlation, namely, that of constant baffle pressure drop. The other investigator, as he raised his cooling air temperature, maintained a constant velocity through the cooling passages and found that the rear gasket temperature rose about 1.15 times the increase in cooling air temperature. This test, likewise, was not representative of the conditions of interest in this paper because, in order to maintain his constant velocity, it was necessary to permit the baffle pressure drop to decline substantially as the absolute air temperature increased. A mean between these results, 0.975 or, say, 1.0 is a suitable conversion factor for practical use assuming a constant baffle pressure drop, representing a slight decline in mass flow and a slight increase in velocity with rise in air temperature. (Recognition is due the N.A.C.A. for subsequent exhaustive analysis and publication of sets of equations[5,6] setting forth the complex heat transfer relations rigorously.)

Using the above experimentally determined relations, cylinder temperature is approximated by an equation combining them, as follows:

$$T_H = K(\text{I.hp.})^{0.4}(\text{lbs./I.hp.Hr.})^{-0.55*}(\text{B.P.D.})^{-0.27}\sigma^{-0.27} + T_A$$

where T_H = maximum rear spark plug gasket temperature °F.;
K = a proportionality constant;
I.hp. = brake plus friction plus supercharger horsepower;
B.P.D. = baffle pressure differential (in. H_2O);
σ = air density relative to sea level;
T_A = entering cooling air temperature °F.

A direct reading chart is more useful for practical assistance to the airplane manufacturers than such a formula. Conversion of brake horsepower and specific consumption to indicated values must first be made in either case, and graphical means is best adapted to accomplishing this. Two formulas would have to be set up for fuel consumptions above and below best power.

Any correlation chart of engine cooling variables should be successful, though not mathematically precise, which can (a) convert brake horsepower and brake specific consumption to indicated values; (b) supply the numerically correct relation of temperature difference to indicated horsepower, for chosen fixed values of all the other cooling variables; and then, (c) make successive corrections to this temperature difference for deviation from these assumed values of each of the other cooling variables. Having thereby arrived at a corrected temperature difference between cylinder and air, it is only necessary (d) to add the cooling air temperature to obtain the cylinder head temperature (the conversion factor for this relation being 1.0, as explained above). This procedure is followed exactly, details of the chart being best provided by following through a specific example. (See Fig. 2.)

* This exponent applies for mixtures richer than that for best power

Example:

Given: Wright Cyclone G or G 100 engine, 850 b. hp., 2100 r.p.m., 0.7 specific consumption, 6 inches water baffle pressure drop, 6000 feet pressure altitude, 41°F. cooling air temperature.

Find: The maximum rear head temperature to be expected.

First, convert the brake horsepower to horsepower per cubic inch displacement. Enter the chart with this value of 0.47 at A, proceed horizontally to the sloping line representing 2100 engine r.p.m. at B and turn downward. Friction and supercharger horsepower have not been added to the brake horsepower, as shown by the indicated horsepower reading on the bottom horizontal scale (which is for explanatory purposes only and need not be read in normal use of the chart).

Proceeding downward from B, intersect the sloping line in the lower left-hand section of the chart at C. This line has a slope of 0.4 (the exponent of variation of temperature difference with indicated horsepower). The line approximates the numerically correct relation of temperature difference for various indicated horsepowers, the other variables being assumed held at specific values, namely: fuel consumption at best power, baffle pressure drop at 6 inches of water, cooling air density at sea level, and carburetor air temperature at 60°F. The relation represented by this line was determined from the compilation of multi-cylinder dy-

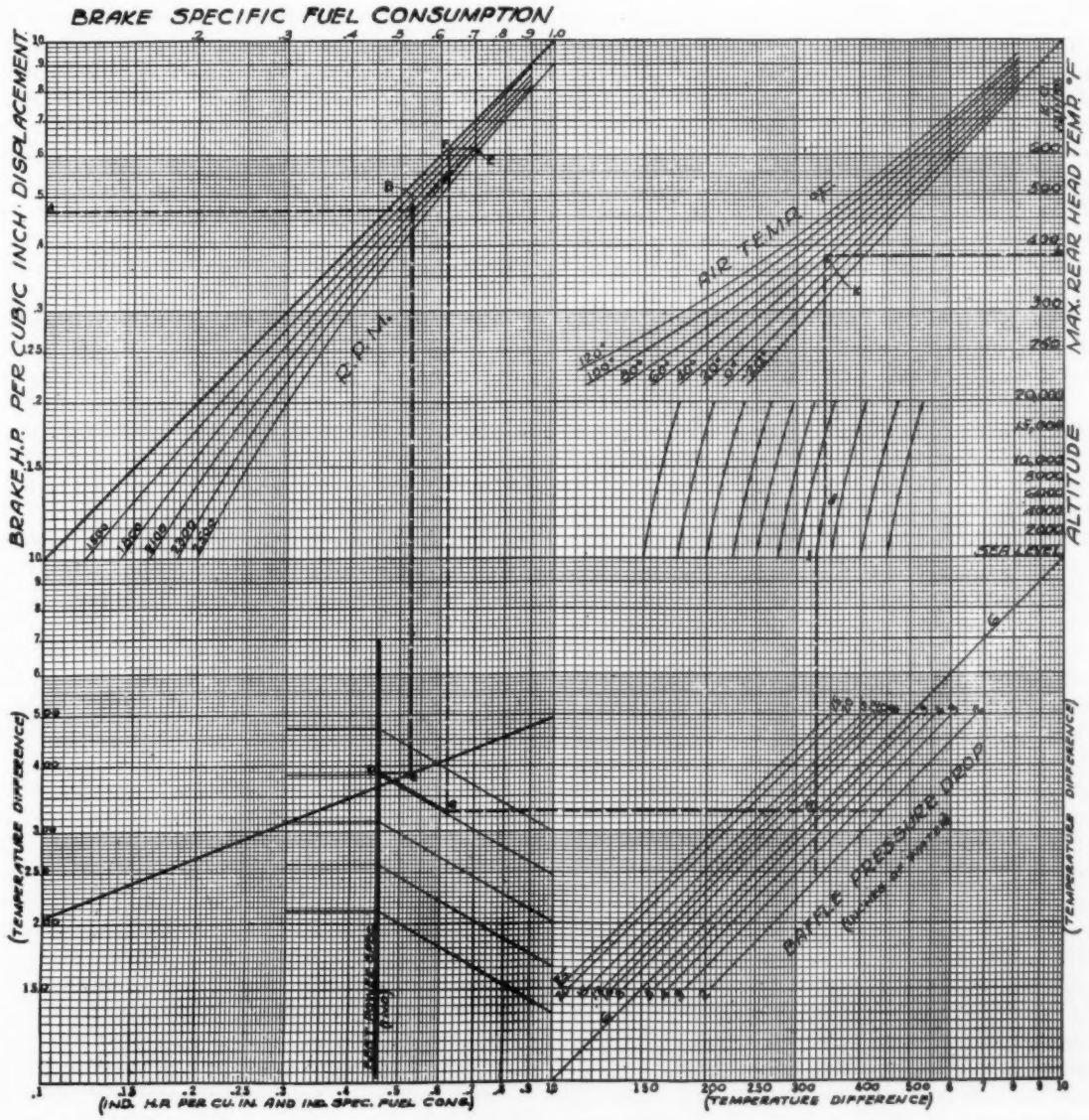

FIG. 2. Cooling variable correlation chart. Relation of maximum rear head temperature to: brake horsepower per cu. in.; revolutions per minute; lbs. of fuel per b. hp. hour; baffle pressure drop in H_2O; pressure altitude in feet; cooling air temperature in degrees F. Applicable to Wright engines Series R-1820-G, G-100, and R-2600-A.

namometer test reports referred to above, after correction for adjustment of the widely scattered external cooling conditions to the chosen constant values given. The temperature difference is plotted as ordinate, but again is not normally referred to.

The bottom scale is used for two variables, and reference is now made to its use for indicating specific fuel consumption. The vertical line at D represents best power specific consumption on an indicated horsepower basis. Transpose C horizontally to D because best power specific consumption was one of the specifications in establishing the temperature difference represented by point C. For fuel consumptions richer than this value, the temperature difference found thus far must be corrected downward, and the path through the chart, therefore, turns downward from D parallel with the family of guide lines provided, whose slope represents the exponent minus 0.55 given for this relation. This downward slope of the path from D is terminated when it reaches the indicated fuel consumption value, which must now be determined.

It is only necessary to proceed from point B in a direction parallel to the main diagonal line to intersect the brake specific fuel consumption value of 0.7 under consideration shown on the top scale, intersecting this value at point E and then turn left horizontally back to the diagonal line at F. This converts the brake specific fuel consumption to an indicated horsepower basis because it has been reduced by the same percentage that the brake horsepower was increased. Proceeding vertically from point F, the downward correction of best power temperature difference from D is terminated by intersection with this path at point G.

Proceeding horizontally to the lower right-hand portion of the chart, it will be observed that if the path intersects the line marked 6 inches baffle pressure drop at H and then turns upward, no change in temperature difference takes place (now readable on the horizontal scale, if desired). However, the other lines representing other baffle drop values are disposed with respect to the six-inch line so that the -0.27 exponential relation with temperature difference given above is maintained, and if the path turns upward at its intersection with any baffle pressure drop line desired, corresponding correction to temperature difference is made.

Only one other correction to temperature difference is now to be made, namely, that of air density as related to pressure altitude. If sea-level density is under consideration, the path proceeds straight upward without making any correction for altitude, but for altitude values, the path should deviate parallel to the guide lines shown on the chart to the altitude desired, illustrated by points (I and J), and then proceed straight upward again. The effect of this deviation is to increase the temperature difference with increasing altitude inversely as the 0.54 power of the mass flow or, at constant baffle pressure drop, as the 0.27 power of the relative density.

All the essential corrections to temperature difference between cylinder and cooling air are now made. By proceeding vertically to the sloping line corresponding to the prevailing air temperature, as at K, and then to the scale at the right, an increment corresponding to the air temperature has been added and the line is terminated at L at a value which approximates the maximum rear spark plug gasket temperature to be expected, 380°F. for this example.

One variable has been allowed no influence in the above procedure: carburetor air temperature. It is well established[3] that variation of carburetor air temperature at constant manifold pressure and engine r.p.m. has no influence on cylinder temperature below the limits of incipient detonation. The temperature difference *versus* horsepower relation of the chart was established for 60°F. carburetor air. Technically, therefore, horsepower should always be first corrected to 60°F. carburetor air at the same manifold pressure, before applying the chart. Practically, however, this correction is slight except at high altitudes where the air is very cold, and in view of the possible necessity of applying carburetor heat, it was considered conservative to exclude it.

By the use of this chart, some error must be introduced in making the corrections consecutively, and slightly different answers could be obtained depending upon which variable was chosen first. In spite of this defect, however, checks made both of engine laboratory and occasional field flight test results, where complete data have been taken, have been reasonably consistent.

One very recent check of accuracy is submitted in Table 1, which compares observed maximum head temperatures obtained under various flight conditions with temperatures calculated from the corresponding observed values of the cooling variables. Identification of these readings in the log sheets is given in the table. These data (selected at random with no exclusions) are from flight tests currently being conducted for purposes other than the subject under discussion, the equipment being a Wright Cyclone GR1820G102 engine installed in a well known transport airplane.

While the spread of the variables indicated in Table 1 is not as wide as might be desired (the tests not having been intended for the present illustration), it is nevertheless substantial, and indicates the consistent results obtained from use of the chart, the predicted temperatures running, generally, a little higher than the observed.

The calculated results of Table 1 are based on the mean of baffle differentials measured at the top and bottom of the engine. It will be observed that for certain readings representing low air speed and high angle of attack, a very large percentage difference exists between baffle pressure differentials taken at the top and bottom of the engine (Test Series 2, time: 4:55 and 4:59). In these cases, the mean of the two

baffle drops differs greatly from the lower value causing the poor cooling condition, and using the mean value a serious discrepancy in calculated temperature results. When the actual lower value of baffle drop is used, the result again becomes consistent with the others.

Regarding the prescribed method of measuring baffle pressure drop in flight, the chart is derived from blower cooled dynamometer stand tests, wherein accurate measurement of pressure differential across the engine is easy and may be accomplished in a number of ways. In airplanes, however, markedly different pressure readings in front of the engine are obtainable in different locations and with different measuring tube devices. The method of front pressure measurement prescribed for airplane use for simulating pressure readings observable in dynamometer ducts, and thus for making the chart applicable, is to use a total pressure tube, pointing forward, above the head fins, midway between the rocker boxes whose tip is just inside the entrance to the head baffle passage. A closed tip static tube behind the cylinder head may be used for rear pressure, and location of this tube is not critical, but the tube should lie in a fore and aft direction.

When the chart is used to perform its usual function of determining required baffle pressure drop, the operator works from both ends of the chart toward the center. The two groups of engine cooling variables, internal and external, have been separated on the chart by the baffle pressure drop correction lines. The paths through the two groups intersect in this region at right

TABLE 1

Comparison of Observed and Calculated Cylinder Head Temperatures Wright GR1820G102 Engine in Transport Airplane

Test Series	Time	Flight Régime	b.hp.	r.p.m.	Spec. Fuel Cons.	Baffle Press. Drop	Air Temp.	Alt.	Max. Head Temp. Obs.	Max. Head Temp. Calc.
2	11:49	Cruise Climb	593	1900	.546	3.8	53	10,500	412	435
						5.4				
	12:38	Cruise Climb	584	1910	.493	3.6	50	11,000	427	450
						5.4				
	1:07	Cruise Level	603	1810	.477	9.3	54	5,000	346	360
						9.8				
	1:21	Cruise Level	603	1810	.448	9.1	54	5,000	360	360
						9.4				
	1:34	Cruise Level	720	1810	.547	10.8	56	5,000	330	345
						11.8				
	1:45	Cruise Level	679	1810	.556	10.1	55	5,000	331	345
						10.0				
	2:06	Cruise Level	430	1810	.540	8.5	59	5,000	324	345
						7.3				
	2:14	Speed Power	905	2200	.627	14.0	55	5,000	340	360
						12.4				
	4:55	Single Level	845	2200	.689	3.0	52	5,000	443	420
						5.5				455*
	4:59	Single Level	855	2200	.606	3.2	52	5,000	475	447
						5.6				490*
4	5:32	Climb	626	1900	.531	5.3	60	4,000	389	410
						7.0				
	5:56	Cruise Level	601	1800	.478	8.7	58	5,000	364	370
						9.0				
	6:22	Cruise Level	601	1800	.467	11.5	58	5,040	343	355
						12.3				
	6:44	Cruise Level	601	1800	.449	12.6	58	5,000	340	350
						12.8				
5	7:37	Climb	626	1900	.535	7.0	60	6,200	393	398
						7.7				
	8:07	Cruise Level	601	1800	.449	9.9	65	5,000	380	372
						9.6				
	8:36	Cruise Level	601	1800	.479	10.7	60	5,000	356	360
						11.2				
8	1:27	Single Level	660	2200	.670†	5.1	32	13,400	384	405
						4.8				
	2:42	Single Climb	838	2200	.670†	5.4	66	6,560	425	430
						5.6				
	2:54	Single Climb	852	2200	.715†	5.6	67	6,260	409	420
						5.3				

* Using low Baf. Press. Drop listed for top of engine; note large proportional difference in B.P.D. resulting in a large error by averaging.

† Based on fuel/air ratio.

angles and the point of intersection determines the baffle pressure drop required.

A given correlation chart is naturally not applicable to subsequent cylinder designs whose heat transfer rate has been increased by improved fins. Performance of such designs may be approximated by lowering the temperature difference—horsepower relation line. It appears that for the Cyclone G200, which has head fins up to $2^1/_2$ inches high, this line should be lowered in the neighborhood of 40° to 50°F., resulting in large reductions in required baffle pressure drop and power to cool. As previously discussed[2], this is to be expected, and is the principal objective of fin improvement at some expense in added fin weight.

The grouping of the variables makes it possible quickly to examine the effect of specific assumed changes in either internal or external cooling conditions, and thus study the relative importance of the several cooling variables in influencing the cooling requirements. Some of the relations thus revealed are worthy of attention.

Specific Conditions Applied for Study of Variables

The influence of cooling air temperature on baffle pressure drop required is, to many, surprisingly great. As an example, suppose 400°F. head temperature be assumed, and assume also that the engine operating conditions as a group require 6 inches of baffle pressure drop at 60°F. cooling air temperature at sea level. On the chart, the reader starts at 400°F. head temperature, proceeds inward horizontally to the 60° line and downward until he intersects the 6 inch baffle pressure drop line, and then draws a horizontal line through this point which represents the assumed engine cooling conditions. Suppose now that with the engine operating conditions remaining the same the cooling air temperature is raised to 110°F. Following through the same procedure on the chart, but using the higher cooling air temperature, it will be observed that approximately eleven inches of baffle pressure drop is required to maintain the same 400°F. head temperature, instead of the 6 inches required under standard cooling air temperature conditions. One tends to be deceived by the fact that cylinder temperature increases only 50° with a 50° increase in air temperature. However, the baffle pressure drop increase required to reduce the temperature difference sufficiently to restore the original head temperature varies approximately inversely as the *3.7 power of the desired reduction in temperature difference*. Thus, while baffle pressure drops required to cool may be moderate for standard conditions, those required with warm air can be relatively large unless higher head temperature limits or richer mixtures are allowed.

A higher allowable head temperature limit makes a correspondingly large reduction in required baffle pressure drop since it increases the temperature difference permissible and reduces the baffle pressure drop required inversely as the 3.7 power of this temperature difference. In the above example, if the limit is raised to 450°F. instead of 400°F., the baffle pressure drop required is restored to 6 inches, at the 110°F. air temperature.

This sensitive relation between cooling air temperature and required baffle pressure drop leads, in turn, to a surprisingly large difference in cooling drag necessary for standard and extreme air temperature conditions. We have just demonstrated that for a change in cooling air temperature from standard temperature to standard plus 50°F., the baffle pressure drop required to maintain the same head temperature is increased 83 percent. This, in turn, reflects a volume of airflow through the cowling increased by about 35 percent. The necessary cooling drag, which is proportional to the product of baffle pressure drop and volume is therefore *increased two and one-half times solely because the cooling air temperature is 50°F. higher than standard.*

Most specifications are drawn for standard conditions. For example, engine specifications are drawn for standard carburetor air temperature, and when extreme air temperatures exist, due allowance is made for the reduced performance resulting. If cooling specifications are, on the contrary, based on extreme air temperatures, then a severe high speed penalty enters into airplane performance rating which is undeserved if all other performance ratings are to be based on standard conditions.

It is true that in an airplane the extreme air temperature cooling requirements must be capable of being met. Unfortunately, if a non-controllable cowling system is used, this severe drag penalty is built permanently into the airplane. With a controllable cowling, on the other hand, a cooling drag of 40 percent of this value may be taken advantage of when flight air conditions are standard, and still less when flight air temperatures are below standard conditions, with correspondingly increased actual airplane speed. If controlled cooling were universally used, airplanes would fly faster most of the time, and cooling air temperature variation could be treated in a manner similar to carburetor air temperature variation in the interpretation of airplane speed performance tests.

Another interesting cooling relation which has heretofore been somewhat difficult to establish is the comparison of baffle pressure drops required for rich rated power operation and lean cruising operation. The following example demonstrates why specific answers to questions on this and other cooling subjects have, in the past, been rather vague:

Assume 900 and 450 hp. operation on a Cyclone engine at 2200 and 1800 r.p.m., respectively, and at 0.75 and 0.50 brake specific consumption, respectively. Assume also that in the case of rated power, 450°F. head temperature is permissible, while in the case of

cruising power 375°F. is called for. Assume 100°F. cooling air temperature in both cases. Application of these values to the chart shows that $4^1/_2$ inches of baffle pressure drop is required for the rated power case while about 8 inches is required for the cruising case. On the other hand, had 400°F. head temperature been permitted in the cruising case this unfavorable value of baffle pressure drop would have been reduced to 6 inches; and had 400°F. head temperature been specified for the rated power also, the relative baffle pressure drop requirements would have been reversed, rated power requiring about 7 inches. If the further assumption is made that the cruising air temperature is reduced to 80°F., cruising baffle drop further substantially declines, permitting the lower head temperature requirement first assumed.

It thus becomes apparent that there are as many answers as there are conditions to choose; by means of the cooling variable correlation chart the airplane manufacturer can obtain a rational reply to the question he has been asking for several years: "How much baffle pressure drop does it take to cool an eng ne?"

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Book Review

The Internal Combustion Engine, by Lester C. Lichty; McGraw-Hill Book Company, New York and London, 1939; 603 pages, $4.50.

The Internal Combustion Engine by Robert L. Streeter, first published in 1915, was widely used as a textbook in the universities and colleges. During the past ten years this book has been rewritten twice by Professor Lichty. In the present edition nearly all of the material in the original book has been replaced in order to keep step with the development of engine theory. Descriptive matter is now almost entirely eliminated and emphasis placed on the thermodynamics of the engine and interpretations of important engine researches.

The principles of engine thermodynamics are stated briefly, perhaps too briefly, for the student who has not had an excellent elementary course in this subject. The treatment of combustion is simplified by the use of the pound-mol system of units and chemical energy values in place of the conventional heating values. The difficult and involved subject of chemical equilibrium is well presented; sufficient material is included to illustrate the method of approach, and resort is then made to charts and diagrams for actual solutions of combustion problems. Calculation for the efficiency of the thermodynamic cycle and the various losses inherent in the real cycle are refined until the calculated fuel consumption checks very closely that obtained in modern engines. This eliminates the term "relative efficiency" so often used to supplement inadequate theoretical computations. Data from several recent authorities on exhaust analysis have been correlated, providing a comprehensive treatment of this important phase of combustion study

The chapter on fuels includes some fundamental information on the molecular structure of liquid fuels and the characteristic of the principal group classifications, with particular reference to anti-knock quality. Gaseous fuels are treated briefly, as are fuels for the compression-ignition engine. Methods of tests for Octane and Cetane numbers are explained in detail. Combustion chamber design for both gasoline and Diesel engines are treated at some length, and experimental data on the behavior of fuel systems for compression-ignition engines are included in the chapter on carburetion and fuel injection.

Special emphasis is not placed on problems connected with any particular type of engine, but the majority of applications are related to automotive motors. A number of aircraft engine problems have been introduced, such as the design of cooling fins, a brief treatment of torsional vibration, and supercharger performance, but the rapid advance in aircraft development would seem to merit increased attention. Radial engine crankshafts and master and articulated rod analysis are not treated in the chapter on mechanics of the principal moving parts.

The book contains a great deal of valuable experimental data and is distinctly in line with the trend in education toward fundamental theory as opposed to detailed descriptive matter. The number of equations developed for the solution of specific problems has been kept a minimum, thus giving the student the opportunity to think his way through, and reducing the tendency to solve problems by substituting in the handbook formulas.

Tables and charts used for the solution of problems are grouped conveniently at the end of the book.

It is primarily a textbook but contains a wealth of material and will be found a valuable reference volume for those dealing with the design and development of internal combustion engines of any type.

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Corrugated Panels under Combined Compression and Shear Load

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SUMMARY

An investigation was conducted on a semi-monocoque box beam to determine the combined stress interaction curve for a corrugation-skin type of construction under combined compression and shear load. The investigation included the determination of initial buckling stresses and a comparison of measured stresses with computed stresses on the box beam.

The interaction curve presented is most closely represented by the expression $R_c + R_s^{1.7} = 1$ where R is the appropriate stress ratio. Curves of effective width of skin *versus* corrugation stress, initial buckling stresses for several skin thicknesses, as well as the combined stress interaction curve are included.

INTRODUCTION

IN DEALING with a composite structure of the box-beam type it is impractical to attempt to determine the allowable combined stresses directly. The most suitable method for evaluating test results seems to be the "stress ratio" method[4,5]. This method (which might more suitably be called the "load ratio" method) consists of the determination of the effect of one type of loading upon the others. The results are presented by means of an "interaction curve," which gives a graphical picture of the entire range of combined loads. In determining points for this curve, test loads are reduced to non-dimensional form by using the ratio of applied load to ultimate load for the simple loading condition.

The true shear and compression interaction curve is known for only a few structural materials and shapes and technical literature offers practically no information on the interaction curve for a box-beam type of construction. Donnell[1,2] conducted a series of tests on small unstiffened cylinders and obtained a cubic parabola for the combined stress curve which has been generally applied to all types of structures. However, because of the type of construction of the test specimens, there is some doubt as to whether the curve applies to more complicated or larger structures. C. P. Grady[10] conducted a series of tests on corrugation caissons in torsion and compression and obtained the peculiar curve given in his paper, reproduced in Fig. 7 of this paper. There is some question as to the validity of his test methods and results, due to the fact that no account was taken of the local bending stresses due to torsion at the ends of the test specimens. Several other investigations have been made on this subject but a discussion of the results is beyond the scope of this paper.

Presented at the West Coast Annual Meeting, I.Ae.S., Pasadena, California, June 17, 1939.

DISCUSSION

Since information on the strength of corrugations under combined loads is practically non-existent, the Lockheed Aircraft Company considered it desirable to conduct a comprehensive investigation to obtain information on the allowable stresses in combined shear and compression. The present paper treats of the results of the investigation to date.

To make the results directly applicable to a wing structure, a box beam to which bending and torsional moments could be applied was chosen as the most suitable type of test section for the investigation. With a corrugation-skin panel on top and a stiffener-skin panel on bottom, the box represented a common form of wing construction. The top panel can be loaded in shear and compression by applying bending and torsional moments simultaneously, just as in the actual airplane.

With this type of construction several problems are involved which must be solved before proceeding with the investigation of combined stresses. First, since it is desired to deal with effective widths in determining the compressive stresses, it is necessary to know the actual effective widths of skin acting with the corrugations at all stresses in order to compute the section properties of the box. This can be accomplished by measuring the effective widths in flat panels under compression.[11] Secondly, the stress concentrations due to bending stresses at the ends of the box caused by torsion must be eliminated. This can best be accomplished by properly reinforcing the ends with doubler plates. Finally, the method of applying the moments to the box must be such that any amounts of torsion and bending can be applied simultaneously without introducing direct shear into the loading system.

DESCRIPTION OF APPARATUS

The box beam was constructed in a manner closely approximating the structure in a semi-monocoque wing. Its cross-section was rectangular, with .091 in. 24ST Alclad vertical shear webs on each side, a bottom skin-stiffener panel of .064 in. 24ST Alclad skin stiffened with 24SRT Alclad "J" sections and a removable top skin-corrugation panel composed of 6 loops of 24ST Alclad "omega" type corrugations of .032 inches thickness covered with .032 inches 24ST Alclad skin. The box was $56^3/_8$ inches in length, 10 inches deep, and $15^1/_2$ inches wide, and was divided longitudinally into five bays by three truss-type ribs

of the general type used in wing construction. The three equally spaced bays in the center were 12 inches, and the two end bays, $10^{3}/_{16}$ inches each. Fig. 1 gives the exact shape and dimensions of the cross-section of the box in the three center bays.

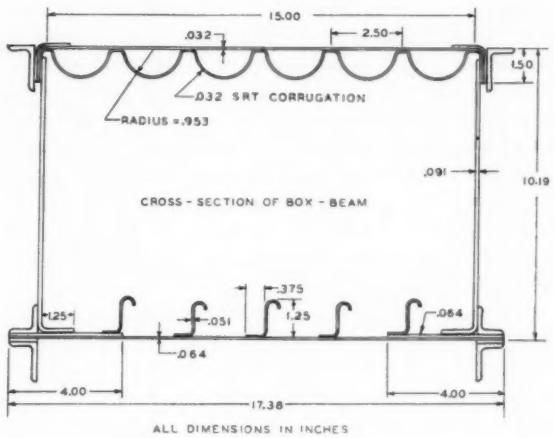

FIG. 1.

Particular care was used to eliminate end effects as much as possible. To do this, three tapering doubler sheets were riveted on the outside at the ends of each panel, and the rivet spacing was varied from $^{5}/_{8}$ in. at the ends to 1 in. constant across the center bay. Examination of Fig. 7 shows that end effects were greatly minimized on the failed panels but not entirely eliminated. This will be discussed later.

One end of the box was bolted to the rigid test stand by means of bolts and steel angles and the other end was bolted to a steel test jig in the same manner. The loads from the test jig were transmitted to the top panel through specially designed 14ST attachment forgings riveted to each loop of corrugation. The corners of the box were reinforced longitudinally by 24ST extruded angles to prevent local failures.

The top skin-corrugation panel was bolted to the box in a manner such that it could be removed and replaced with another similar panel. It was so designed that, when moments were applied to the box, failure would occur in it before permanent set took place in any other portion of the box. In this manner the box could be used for a number of tests by merely replacing the failed panel with a new panel. The general construction of the box is shown in Fig. 2.

Six identical panels as previously described were prepared for the top of the box to be tested under various amounts of compression and torsional shear. Several additional panels were also prepared including a spot-welded panel of the same gage as the six previous panels and several .064 in. corrugation-.032 in. skin panels with a countersunk type of rivet.

A standard Lockheed test jig was revised for this investigation. It consisted of a rigid steel back plate heavily reinforced, and a steel tripod on the forward end of the box. Fig. 3 gives the details. Plate gages* of 40,000 pounds capacity, calibrated to read small increments of load were used under the screw jacks. The accuracy of these plate gages was better than 1 percent and thus the possibility of large error in determining the failing load of the panel was considerably small. The jack on the outboard end could apply bending moment to the box, and torsion was applied through arms extending to one side. Shear was taken out by the jack at the outboard end of the box, thus insuring that only pure torques and pure bending moments were applied to the test section.

The shear, bending, and torsion loads were read directly from the plate gage at the jacks. Extensometers (Huggenberger) were located at various points on the test specimen (both upper and lower surfaces, span-wise and chord-wise) enabling the stress distribution to be checked. For torsion loadings the extensometers were placed at an angle of 45° with the longitudinal axis of the box. For bending loads the extensometers were placed parallel to the longitudinal axis. On the top of the test panel the extensometers were placed along rivet lines where buckles in the sheet

* A special plate gage was used in these tests. This plate gage consists of a highly heat-treated steel plate supported on knife edges, and deflections of the plate under load are magnified by a lever system and read on an ordinary Ames dial gage.

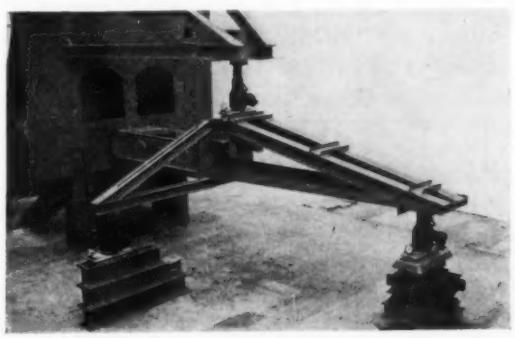

FIG. 2. View of test set-up and general construction of box beam.

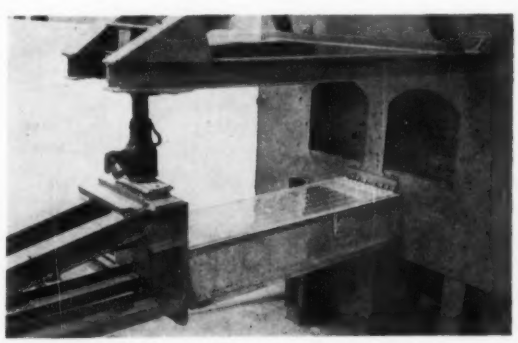

FIG. 3. Close-up of test panel. Note the design of the doublers and rivet spacing at end of panel

would not develop till comparatively high stresses had been attained.

Test Procedure

A preliminary investigation was first conducted on flat panels in shear and in compression to determine the allowable flat panel stresses as a basis for predicting the ultimate stresses in bending and in torsion of the top panel on the box. The shear panels were tested in a parallelogram steel jig, 12 inches by 12 inches, and the panels in compression were tested as described in Ref. 11. It is important to note that over 50 compression panels in various lengths were tested to establish the effective width curves given in Figs. 4 and 5.

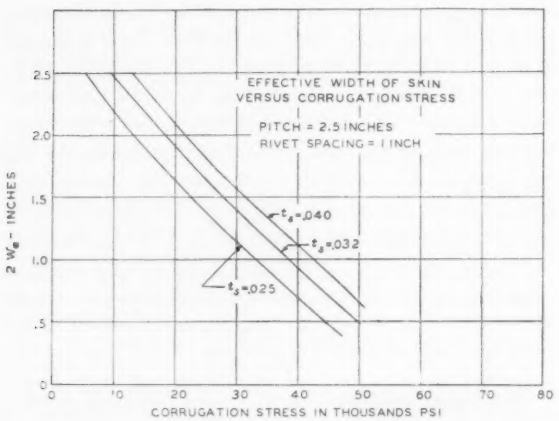

Fig. 4.

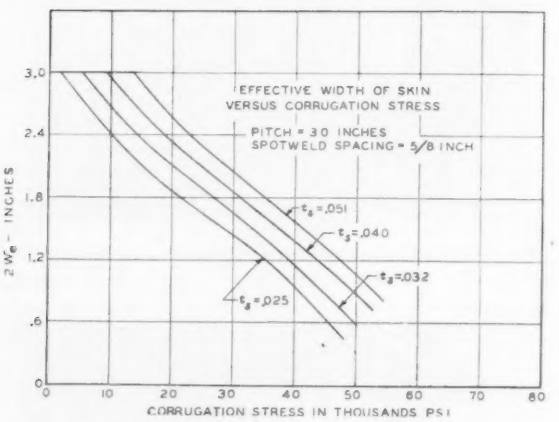

Fig. 5.

After mounting the necessary strain gages on the box beam, loads were applied with the three jacks, giving bending, torsion, or any desired combination of the two. The total shear was balanced out by means of the shear jack at the outboard end of the beam. The load was applied in increments of approximately 10 percent.

One panel was tested in pure torsion alone, and one in pure bending alone, to determine the shear and compression stresses for a comparison with the stresses in the flat panels. The remainder of the panels were tested in combined bending and torsion. When extensometers were mounted on the box, the loads were applied in small increments and instrument readings taken at each increment. After the initial buckling of the panel had occurred, special attention was paid to the wave pattern, and also the strain gage readings, to insure that equal distribution of load across the entire panel was being obtained. However, few extensometers were used with high torsional loadings as the direction of the principal stress is difficult to determine accurately and, in addition, buckling occurs at such low loads that strain gage readings cannot be relied upon at the high stresses.

For combined loadings, equal increments of bending and torsional moments were applied simultaneously to the specimen until the lower of the two desired moments was reached, when loadings were then continued up to failure in the appropriate remaining condition. (This point is mentioned because the manner of approaching the failing load may have some bearing upon the results.)

Presentation of Data

The torsional moment was determined by multiplying the load in the torsional jack by the distance between this jack and the shear jack. Torsional shear stresses were determined from the formula $f_s = M_t/2At$ by the shell analogy, where t is the total thickness of skin and corrugations on the top panel and A is the enclosed area of the box measured between center lines of the webs and center lines of the top and bottom panels, the center line of the top panel being taken as the lower surface of the top skin. The application of this formula was checked by extensometer readings at low stresses before initial buckling occurred in any portion of the box.

The beam bending moment was determined by multiplying the load in the bending jack by its arm to the shear jack. Bending stresses were determined from the classical beam formula $f_b = M \cdot y/I$, where I is the moment of inertia of the box. The true effective width of buckled skin acting with the corrugations on the compression side was used, calculated by the method presented in Ref. 11. By taking the effective width at various stresses, calculating the moments of inertia of the box, and from this determining the necessary bending moments to obtain these stresses, a curve of corrugation stress *versus* beam bending moments could be plotted as shown by the upper curve in Fig. 6. In this manner the compressive stress in the skin on the top panel could easily be read for any given bending moment thus eliminating the process of trial and error. Bending compressive stresses were calculated at the outer fiber of the top skin in all cases.

The results of the investigation are tabulated in Table 1. Six skin-corrugation panels were tested to determine the shape of the interaction curve, and four other miscellaneous panels were tested to determine the effects of types of skin attachment to corrugations. The first six panels are designated by numbers from one to six and the other four designated by numbers and letters as given in Table 1.

Panel No. 1 was tested in bending alone but failure occurred at the end attachment fittings due to improper attachment of the top skin to the fittings. This necessitated testing a second panel in bending alone, panel No. 5. Failure in this panel occurred at a rib attachment and an ultimate compressive stress of 45,000 lbs. per sq.in. was obtained. This was somewhat below the stresses in the flat panel tests, and was due to the normal load imposed on the corrugation loops by the ribs because of the rigidity of the box. This is a condition often obtained in semi-monocoque beams under bending and must be considered in the design of such structures. The ultimate bending moment on the box at failure was 977,000 in. lbs., which was of sufficient magnitude to insure accurate results. Fig. 8 shows the failures in both panels.

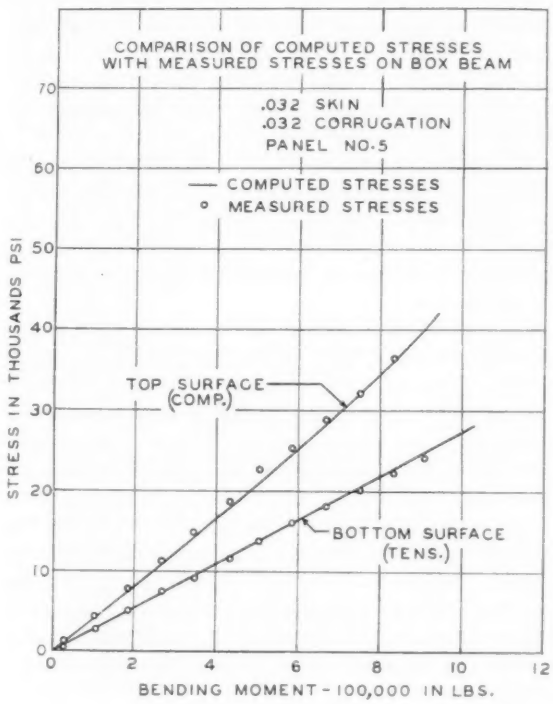

FIG. 6.

Extensometers were mounted on the box for test No. 5 and the measured stresses are compared with the calculated stresses in Fig. 6. The agreement is excellent up to a maximum compressive stress of 37,000 lbs. per sq.in., above which no stresses were measured because the proportional limits of the corrugation material had been reached and also because inter-rivet buckling occurred where the instruments were mounted. This agreement indicates that the method of computing stresses on the box by using effective widths is valid.

Panel No. 2 was tested in torsion alone and failure occurred at a torsional moment of 435,500 in. lbs. producing a shear stress in the top panel of 21,900 lbs. per sq.in. This compares very closely with the results of the flat panel tests in which an average stress of 22,000 lbs. per sq.in. was obtained from 12 panels. Panels Nos. 3, 4, and 6 were tested under various amounts of torsion and bending and the results are given in Table 1. Panel No. 4 failed due to a slight local buckling and, hence, gave results slightly low.

The combined stress curve for the corrugations is plotted in Fig. 7 using the results from panels 1 to 6. All six panels were made from the same stock of material, thus eliminating material variations from the results. Fig. 6 gives a comparison of the types of failure obtained in the various tests and it is interesting to note the change of angle of failure proceeding from the panel in torsion alone to the panel in bending alone.

Panels A-1, A-2, and A-3 failed by the countersunk rivets pulling through the top skin due to the buckles

TABLE 1

Panel No.	Corrugation	Skin	Attachment	Ult. Comp. Stress (f_c)	Ult. Shear Stress (f_s)	Comp. Stress Alone (f_{co})	Shear Stress Alone (f_{so})	f_c/f_{co}	f_s/f_{so}
1	.032 24SRT	.032 24ST	1/8 brazier rivets	35,000	0	45,000	21,900	.778	0
2	.032 24SRT	.032 24ST	1/8 brazier rivets	0	21,900	45,000	21,900	0	1.000
3	.032 24SRT	.032 24ST	1/8 brazier rivets	19,300	15,300	45,000	21,900	.429	.700
4	.032 24SRT	.032 24ST	1/8 brazier rivets	33,800	8,750	45,000	21,900	.751	.400
5	.032 24SRT	.032 24ST	1/8 brazier rivets	45,000	0	45,000	21,900	1.000	0
6	.032 24SRT	.032 24ST	1/8 brazier rivets	42,700	5,230	45,000	21,900	.949	.239
A-1	.032 24SRT	.040 24ST	*1/8 countersunk rivets	22,000	10,600	45,000	**22,000	.489	.481
A-2	.032 24SRT	.040 24ST	1/8 countersunk rivets	27,300	9,250	45,000	**22,000	.607	.420
A-3	.064 24SRT	.051 24ST	1/8 countersunk rivets	30,200	10,900	**50,000	**22,000	.592	.495
S-1	.032 24SRT	.032 24ST	Spot-welds	36,000	10,300	45,000	21,900	.200	.473

All rivet spacing 1" and spot-weld spacing 3/4"; all stresses in pounds per square inch.

*90° countersink.

** Stresses from flat panel tests. All others from box-beam tests.

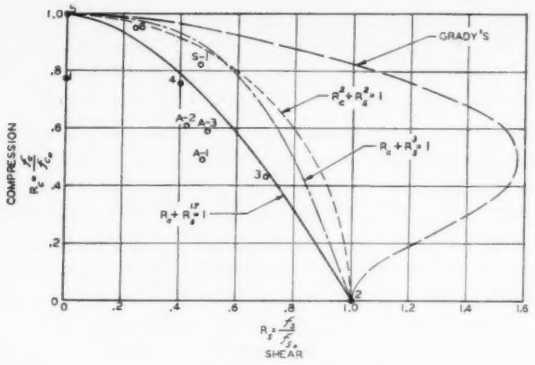

FIG. 7. Combined stress interaction curves; shear and compression.

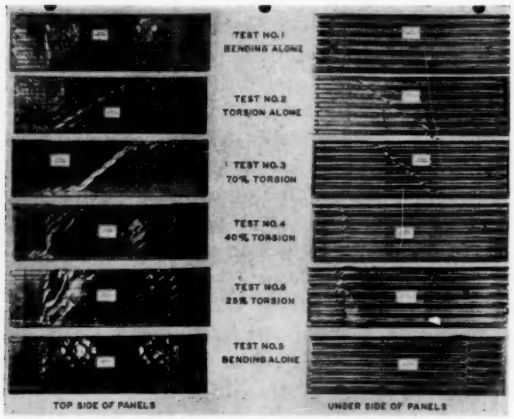

FIG. 8. Comparison of failures on test panels used to determine the combined stress interaction curve.

formed by the combined loads. The results were lower than obtained in the first six tests indicating that closer rivet spacing or better rivets were necessary to increase the strength of the panels. The cause of this reduction was due to the combined stresses buckling the sheet, pulling it off the rivets, and thus reducing the strength of the sheet in compression by increasing the effective rivet spacing. The reduction in shear strength would be small since the shear carrying ability of the skin would be reduced but little. The values of f_{so} and f_{co} for these tests were determined from flat panels as indicated in Table 1.

Panel S-1, the spot-welded panel, sustained higher combined stresses than the riveted panels, which may be attributed to the closer spot-weld spacing.

The combined stress curve is presented in a non-dimensional form so that it may apply to any structures of the same general type. The curve shown in Fig. 7 follows very closely the curve represented by the equation

$$R_c + R_s^{1.7} = 1,$$

where $R_c = f_c/f_{co}$ and $R_s = f_s/f_{so}$.

Conclusions

It is probable that the addition of shear stresses to compression stresses in structures of this type lowers the effective width of skin acting with the stiffeners, but no proof of this is available. However, many investigators have noted that a very small amount of shear load changes the buckles in the skin from pure compression waves to prevailing buckles of the shear (diagonal tension) type, and the observations made during these tests agree. At any rate shear stresses do lower the initial buckling stresses but quantitative data are not available.

With the increased speeds of airplanes the importance of smooth external surfaces is becoming more apparent. Buckled skin presents an aerodynamically rough surface, thus increasing the overall drag. For this reason an observation of initial buckling stresses of the skin on skin-corrugation panels was conducted on both the flat panels and the box beam.

The maximum depths of skin waves at various loads in flat panel tests were measured by taking contours of the skin parallel to the rivet lines and half way between them. The contours were taken by an apparatus at the California Institute of Technology specially designed for the purpose.

Curves of depth of skin waves against corrugation stress for 2.5 and 3.0 inch pitch corrugations are plotted in Figs. 9 and 10. The intercepts of these curves with the abscissae give the initial buckling stresses of the skin for various thicknesses for use in design. These initial buckling stresses agreed fairly well with the results obtained by visual observation from the box-beam tests.

The initial buckling stresses are not necessarily the stresses at which the skin becomes aerodynamically rough. Roughness occurs at slightly higher stresses and from visual observations made on the flat panels, a wave depth of approximately .03 inches was found to be the depth beyond which the skin becomes appreciably rough.

As previously mentioned, end effects were not entirely eliminated from the panel tests. However, they were sufficiently minimized so that a fairly uniform stress distribution was obtained over the top of the test panels. An examination of Fig. 8 indicates that there were practically no end effects in tests 2 and 3. In the other tests final failure occurred near the doublers but permanent buckles may be seen over the entire panel. This would indicate that a fairly uniform stress distribution was being obtained. A check of the extensometer readings also showed that the stress distribution over the panels was uniform. This was especially true of panel No. 5 on which readings were taken up to high stresses.

Since all the panels were tested under identically the same conditions, the final results should not be affected by the slight end effects incurred. However, for future investigations along this line, this problem

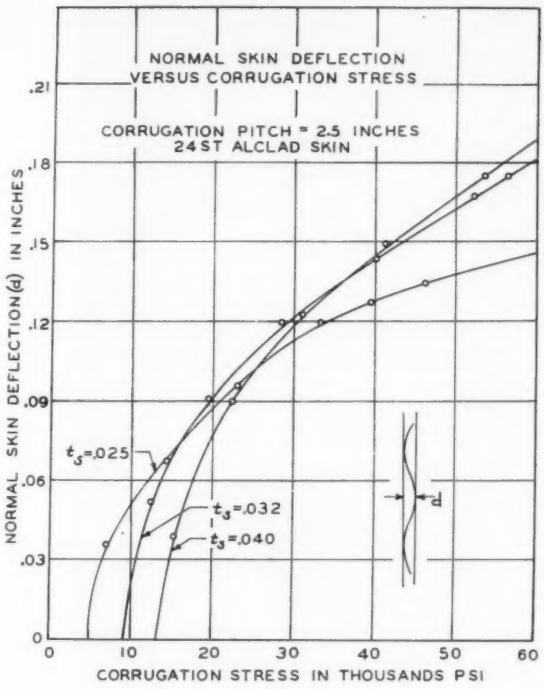

FIG. 9.

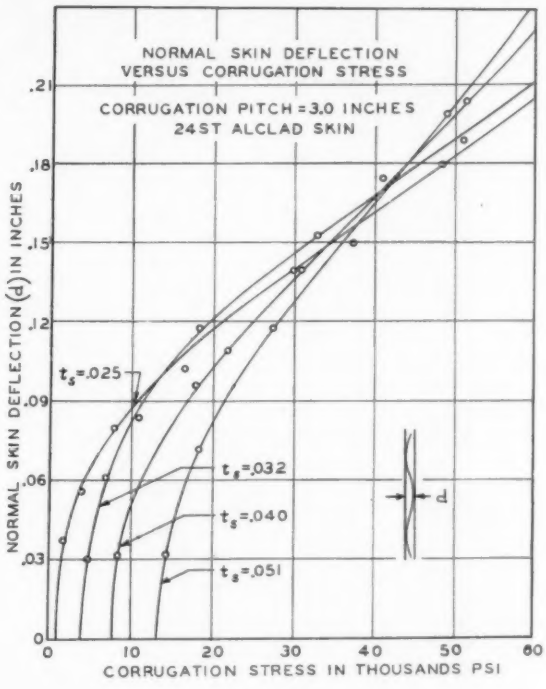

FIG. 10.

should be kept in mind and further attempts be made to eliminate it.

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Book Reviews

Problems in Mechanics, by G. B. KARELITZ, J. ORMONDROYD, and J. M. GARRELTS; The Macmillan Company, New York, 1939; 267 pages, $2.50.

This collection of problems and concise exposition of the principles of mechanics should find wide use in engineering schools. A collection of 782 problems in statics, kinematics, and dynamics, with answers is given. About one-tenth of the problems are solved, in order to demonstrate the principles involved. A wide range of difficulty and an exceptionally wide range of practical applications will be encountered by the student.

The groups of problems grew out of a collection by the late S. V. Mestchersky of the Polytechnic Institute of St. Petersburg. These problems are reworded to suit American practice and many new ones added.

The first 50 pages are an excellent review of the principles and theorems of mechanics. While there are few aeronautical problems as such, a large number of those given are, nevertheless, directly applicable to the field.

Sailplanes, by C. H: LATIMER NEEDHAM; Chapman and Hall Ltd., London, 1937; 268 pages, 6s net.

This book was first published in 1932 and the present edition is an inexpensive reprint with revisions. It gives the detailed technical data required for the design and construction of sailplanes. After a description of unusual designs and auxiliary devices there is a chapter on the characteristics of some of the better known types of sailplanes. A course in the technique of soaring and sailing flight is included.

While the material on piloting is not as extensive as that given in Wolf Hirth's book, "The Art of Soaring Flight," designers and builders of sailplanes will welcome this reprint both because of the low cost and the wealth of material presented.

INSTITUTE OF THE AERONAUTICAL SCIENCES
HONORS NIGHT & ANNUAL DINNER
HOTEL BILTMORE JANUARY 16, 1940
BRUCKER - HILBERT CO.
NEW YORK
0135

Honors Night and Annual Dinner of the Institute of the Aeronautical Sciences

THE Honors Night and Annual Dinner of the Institute, at which awards, Honorary Fellowships, Honorary Memberships, and Fellowships were presented, was held at the Hotel Biltmore in New York on the evening of January 26, 1940. Over 700 members and guests were present.

As there were many speakers on the program it is only possible to print in the Journal excerpts from their addresses.

Address by the Retiring President

Dr. George W. Lewis

This is the Seventh Annual Dinner of the Institute. Though one of the youngest aeronautical organizations in the world, we hope that we have profited from the experience of others—particularly the Royal Aeronautical Society of Great Britain—and have established principles which will carry the society forward steadily, and that we may continue to merit the regard of the leaders of aeronautics in the United States.

I feel that I should pay a tribute, first, to the six past Presidents of the Institute who have laid such a sound foundation that it is easy now to carry on by simply riding on the momentum they started. Dr. Hunsaker was our first President and, to those who know him, he will always be regarded as the greatest, as it was he who gathered around him such a distinguished group that the Institute started with great prestige in membership. Good old Charles Lawrance followed, and with his financial genius placed us on a firm solvent footing. Glenn Martin increased the scope of the Institute by introducing the Corporate Membership idea, which put the Institute on a firm financial basis and permitted us to publish the Journal. Donald Douglas, while he was President, placed at our disposal his genius for organization and, busy as he was, devoted his time and ability to organizing the membership and financial structure of the Institute. Clark Millikan added his scientific attainments to our rapidly growing reputation in the fields of the aeronautical sciences and has been especially helpful in making our technical meetings the great successes they are. Ted Wright, my immediate predecessor, expanded all our work, particularly the Branches, until now the Institute has about three thousand members and adding to each grade steadily.

Tonight is Honors Night when we are pleased to single out distinguished members of our profession and give them credit for their contributions to the advancement of aeronautics. They will receive awards and medals, but I would like to mention a few others who have made noteworthy contributions to the Institute.

The first real benefactor and sponsor of the Institute was Columbia University. It was there in 1933 that we held our first small organization and technical meeting. Each year since, Dr. Butler has placed at our disposal the entire facilities of the Pupin Physics Laboratories and the Men's Faculty Club has always opened its doors to all of our members. I wish to thank him and Professor George B. Pegram, Dean of Science at Columbia, and express our great appreciation and indebtedness to them both. Dean Pegram has been for eight years a great and good friend.

The second I wish to thank is also not a person but an organization—Rockefeller Center. When we were too poor to have even a small office, they added greatly to our prestige by permitting the Institute to occupy beautiful offices then known as The Skyport. Only this month they arranged for us to move to offices which are three times the size of our present quarters. I thank Mr. Lawrence Kirkland and express our gratitude to him and through him to the Board of Directors for its generous treatment. And I will ask Mr. Laurance Rockefeller and Mr. Winthrop Rockefeller, who are also our guests here tonight, to carry a message of appreciation to their brother Nelson, who, as head of Rockefeller Center, has been so considerate.

Very quietly and without much publicity the Institute has, during the past four years, received from the Works Projects Administration generous support for the preparation of an index of aeronautics. We can truly say that we now have what is regarded by everyone as the greatest source of aeronautical reference data in the world. We have over two million references carefully classified. We have published many volumes and distributed them to governmental departments of this and other countries, to the leading universities of the world, and to aeronautical laboratories and aviation companies which maintain libraries. I wish to thank publicly those who have assisted us in this work, in particular, Commissioner McKenzie of New York. I also wish to acknowledge our indebtedness to three other great friends of the Institute, all officials of the Works Projects Administration: Mr. Corrington Gill, Assistant Administrator from Washington; Colonel Brehon Somervell, Administrator for New York, and Miss Mary Tinney, in charge of technical projects. To them I express our appreciation for making it possible for the Institute to acquire such an invaluable reference collection. It is a most creditable accomplishment and will always stand as a contribution to science.

And now I come to some of the noteworthy events of my year as President. We had planned to hold an International Congress of the Aeronautical Sciences in New York last September. Lester Gardner and I visited Europe and invited several foreign governments to send delegates. But we sensed trouble ahead and urged the Council to postpone the Congress for two years.

A great honor came to Lester Gardner during the year, when the membership of the Royal Aeronautical Society, which is the oldest as well as the most distinguished aeronautical organization in the world, bestowed on him its greatest honor by electing him an Honorary Fellow. Only two other Americans have been thus honored—Dr. Orville Wright and Dr. J. C. Hunsaker. In connection with this election, the Royal Aeronautical Society referred to the pioneering work that he has done in establishing the Institute. It was timed most appropriately, as this year Major Gardner rounds out twenty-five years of activity in aeronautics.

As regards the Institute, I would like to add further the appreciation of the officers and the members of our indebtedness to him. At times the President and the officers may call the signals, but he always carries the ball and for the progress that we have made we are grateful to him. He has not spared himself in devoting all his energy to the interests of the Institute and we are most appreciative.

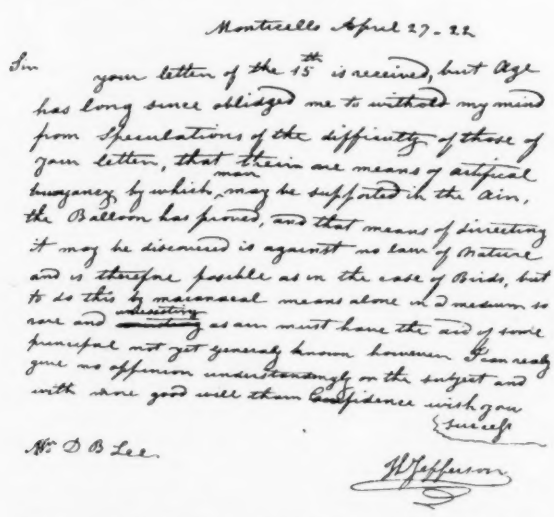
In my Annual Report to the members, I have told in detail the circumstances which led up to the outstanding event of my year as President. We have acquired principally by gift a small but useful library but never believed it would be possible to have, so soon, an aeronautical library which would rank with any in the world. The generosity and farsightedness of W. A. M. Burden who has been collecting all kinds of aeronautical literature for many years has made this possible as he has placed in the custody of the Institute his valuable collection of over ten thousand books, reports, etc. I wish to thank Mr. Burden for myself, the Council, and the entire membership of the Institute for making this year one of the most eventful in its history.

Even before Mr. Burden told us of his intentions, we had the idea of starting a combination of library, index, and museum which is now called The Aeronautical Archives. It should soon become the place where those who have objects of historical interest relating to aeronautics or books which they wish to present for a useful purpose will wish to be represented.

As an instance, when we were in Paris last summer, Mr. Hart O. Berg, who in the early days of flying represented the Wright Brothers in Europe, presented the Institute with his invaluable collection of clippings, photographs, and books about the early days of the Wright Brothers and European aviation. It could never be assembled again, and we are greatly indebted to Mr. Berg for his generous gift.

Last Summer when we were in London we told Mr. C. R. Fairey, the well known English aircraft constructor and a Fellow of the Institute, of our plans for enlarging our library. He offered to place one thousand dollars at our disposal to purchase books in London to add to the collection. We are grateful to Mr. Fairey for his generous gift and have been pleased to make him the first English Benefactor Member of the Institute.

You have found with your program a reproduction of a letter from Thomas Jefferson written at Monticello in 1822. It was written to D. B. Lee. Who Mr. D. B. Lee was we cannot learn



Monticello April 27. 22.

Sir your letter of the 15th is received, but Age has long since obliged me to withhold my mind from speculations of the diffinulty of those of your letter, that there are means of artifical man
buoyancy by which, may be supported in the air, the Balloon has proved, and that means of directing it may be discovered is against no law of Nature and is therefore possible as in the case of Birds, but to do this by mechanical means alone in a medium so rare and ~~resisting~~ as air must have the aid of some principal not yet generally known. I am ready you no opinion understandingly on the subject and with more good will than confidence wish you success

Mr. D B Lee.

Th Jefferson

The Thomas Jefferson letter from The Aeronautical Archives.

as yet, but we may find that he was one of the earliest experimenters in American aeronautics. This letter came to our attention last year and we made the suggestion that it would be a most interesting and valuable addition to the Institute's archives. Mr. E. DeWint Eckerson, who owned the letter, said that he had intended to give it to his nephew, Mr. Howard S. Tierney, Jr., a Senior at Yale University. Mr. Tierney said that he would be glad to have it presented to the Institute. We thank them for placing this interesting historical document in the archives.

Presentation of the Octave Chanute Award

Dr. Lewis

The Institute has adopted a policy of establishing awards in memory of pioneers in American aeronautics. We believe that recalling, each year, the great work of early experimenters is a fitting tribute to those men who laid the foundation on which has been erected such a great new scientific structure.

This year we inaugurate the Octave Chanute Award. Octave Chanute probably did more to stimulate an interest in flying before the Wright Brothers than any other American. He gave lectures which interested other engineers. His book, "Progress of Flying," is one of the early American classics on aviation. He was a distinguished engineer in many fields, as well as a great aviation pioneer. We are pleased to honor him by giving his name to an award for outstanding work by pilots. The first recipient of this award is a pilot and an engineer. The committee that selects the recipient is as follows: Chief of the Air Corps, War Department; Chief of the Bureau of Aeronautics, Navy Department; Director, National Bureau of Standards, Department of Commerce; Chairman, Civil Aeronautics Authority; Director of Research, National Advisory Committee for Aeronautics; President, Institute of the Aeronautical Sciences; Executive Vice-President, Institute of the Aeronautical Sciences.

We have asked Major General H. H. Arnold, a member of the Committee of Award, to present the certificate and tell something of the accomplishments of the recipient.

Major General H. H. Arnold

Without pilots who are not afraid to take risks with experimental models we would be greatly handicapped in our scientific research. This type of flying enables a test pilot to analyze the problems presented by a new plane and solve them step by step. By doing this, the hazard and risk of flying new types may be eliminated and certainly is reduced.

Eddie Allen was born in Chicago in 1896. He left the University of Illinois to join the Army. He transferred from the infantry to the Aviation Section of the Signal Corps and was soon selected as an instructor. In 1918, he was sent on a special mission to Martlesham Heath, England—the R.F.C. flight test center. That was the start of his career as a test pilot. His work in England naturally led to the test flight section at old McCook Field where he landed in 1918 just prior to the Armistice. He did so well at old McCook that he was promoted to test pilot for the N.A.C.A. at Langley Field.

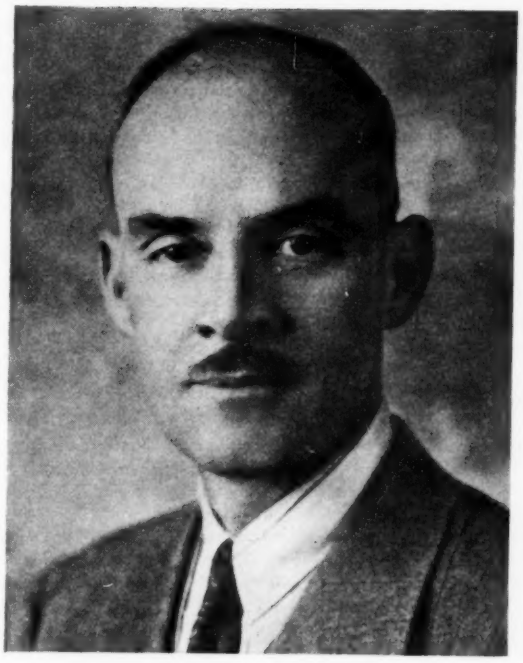
He realized that there was much more to this testing of new equipment than just flying, so he went back to the University of Illinois and then to the Massachusetts Institute of Technology. To further acquaint himself with flying, he started flying gliders. In fact, he took two to France and Germany.

In 1923 he was back at McCook Field as a test pilot. In 1925 he was flying air mail between Cheyenne and Salt Lake City. When Boeing took over the trans-continental air mail in 1927, Eddie went with the others and became a member of the organization of which he now forms a part. He was picked out as a Boeing test and research pilot.

In 1932, Eddie started to do independent work for Northrop Douglas, Vought, Curtiss, United Air Lines, Eastern Air Lines, Pan American, Sikorsky, Vultee, Consolidated, and Boeing. For these companies he tested over 40 different planes and accumulated 6800 hours of flying time.

I think it is indeed appropriate that the Octave Chanute Award be given to E. T. Allen "for his outstanding contributions to methods and procedure in flight research in connection with airplane design and operation."

General Arnold then presented the award to Mr. Allen.



Mr. Edmund T. Allen

Mr. Edmund T. Allen

I am greatly appreciative of the honor that has been bestowed upon me and upon the profession of a test pilot by the presentation of the Chanute Award.

Years ago the test pilot was thought of as a dare-devil that did not understand airplane fundamentals and was unable to communicate with the airplane designers whose technical language he did not speak. Today the test pilot is an entirely different type. There is a large and growing corps of test pilots who do thoroughly understand airplane fundamentals and whose contributions to aviation are greatly enhanced because they are engineers as well as pilots. This occasion marks the definite end of the era of the older conception of test piloting. It marks the coming of of age of engineering test piloting.

On my own behalf and on behalf of other test pilots, I wish to thank you for the recognition you have given to the whole profession through the presentation of this Award.

Presentation of the Daniel Guggenheim Medal

Dr. Lewis

The second honor which we bestow tonight is the Daniel Guggenheim Medal. It was established by that great benefactor of aviation in 1929 and has become one of the greatest honors that can come to anyone. The recipient is selected by a group of aviation representatives from the S.A.E., the A.S.M.E., and the I.Ae.S., representatives of five foreign countries and the previous American recipients of the Medal.

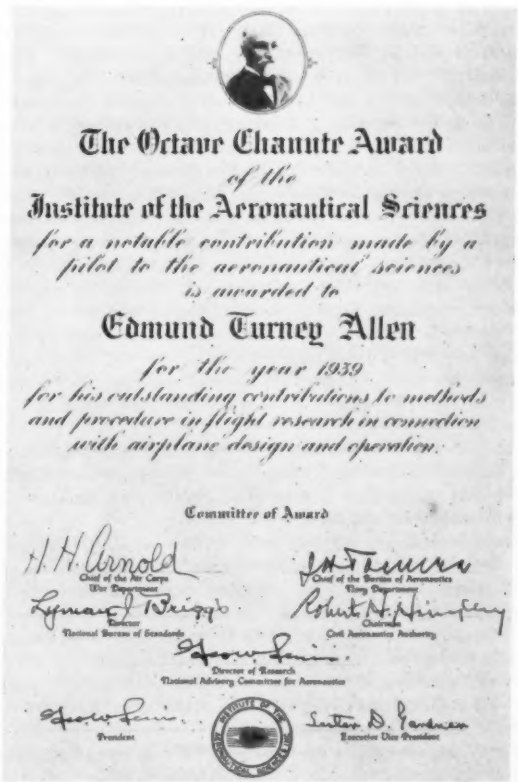
The recipient for 1939 was chosen during my term of office as Chairman of the Medal Board, so I am intimately acquainted with the lengthy list of persons considered. It soon narrowed down to one man, a Fellow and past President of the Institute, as well as one of its Benefactors. It is fortunate that the Chairman of the Medal Board this year happens to know the recipient's work so well. In fact, it can be said that Dr. Hunsaker taught him his first steps along the path that has led him to such great eminence.

Dr. J. C. Hunsaker

I am honored to present before the members of the Institute and their guests the recipient of the Daniel Guggenheim Medal for 1939, Donald Wills Douglas, a past President and Fellow. Most of you will recognize a similarity between his name and that borne by all the main line air transports of this country. A few will recall a young fellow who was appointed to the Naval Academy in 1909 from New York, and thus started on the way to becoming a naval officer.

However, his father was to be disappointed, largely because of stopping off en route to Annapolis to see the Wright Brothers' first airplane being demonstrated. No one can ever know how some people see the shape of things to come. Thousands of others witnessed these early flights and were impressed or entertained by the show, and some may even have indulged in wishful thinking. Douglas, however, found that his vocation to train for a naval officer's duties had lost its force and in 1912 he resigned from Annapolis and went to M.I.T. to study mechanical engineering in preparation for airplane building. Here he made rapid progress, graduating with the degree of Bachelor of Science in Mechanical Engineering in 1914.

In 1913, I had been sent to Europe by the then President Maclaurin of M.I.T. to work in Eiffel's aerodynamic laboratory in Paris and with Bairstow at Teddington in England with a view to building a wind tunnel for M.I.T. on my return. Douglas knew about this, because on my return I discovered that my assistant had already been hired by the M.I.T. authorities, and Douglas was the assistant.



The Octave Chanute Award
of the
Institute of the Aeronautical Sciences
for a notable contribution made by a pilot to the aeronautical sciences is awarded to
Edmund Turney Allen
for the year 1939
for his outstanding contributions to methods and procedure in flight research in connection with airplane design and operation.

Committee of Award

H. H. Arnold — Chief of the Air Corps, War Department
Lyman J. Briggs — Director, National Bureau of Standards
Jerome C. Hunsaker — Director of Research, National Advisory Committee for Aeronautics
Jerome Lewis — President
Santos D. Leadman — Executive Vice President

Mr. Donald W. Douglas

From this date begins my habit of saying "I knew him when." I should now explain how splendid he was as my assistant and should develop my own importance somehow. But Douglas was not cut out to be anyone's assistant—at least not for long. For example, I sketched up a rough apparatus and asked Douglas to make up finished drawings for the shop and to compute the moment of inertia, effect of friction, and other details. Some time later, I tried to check him up but I couldn't find him. I finally located him in the machine shop of another department, where he had an apparatus all finished and was calibrating it by dynamic tests, not by computation as I had directed. Nor had Douglas bothered to make the finished drawings to be checked by me before having the apparatus made. He had taken a characteristic short cut, made the model himself from rough sketches, omitted all the computations by putting on initially large balance weights and then turned them down by successive trials to get the right period of oscillation. Of course, the ordinary assistant would have been fired, but Douglas was not the ordinary assistant. His apparatus was a lot better than my suggestion, cost less and was all done.

I give this trivial incident as typical of qualities of enterprise plus sound Scotch judgment that marked the services of this extraordinary assistant.

The next year Douglas left M.I.T. after having demonstrated that he could, if he wished, have become a leader in scientific research and engineering theory. He joined a new airship company to help build the Navy's first airship.

Glenn Martin was building good airplanes in Cleveland then, and Douglas went with him and in a very few years became Chief Engineer. Naturally, Douglas went into business for himself at the first opportunity. In 1920 he started in California the enterprise that has made him famous. The start was extremely modest with borrowed funds and rented quarters. Douglas was President, Chief Engineer, Chief Draftsman, Superintendent, and Foreman. He built the "Cloudster," a remarkable anticipation of a transport airplane.

The Navy, to whom it had not been offered, saw at once that if it would carry a torpedo, it might be important. I was then in the Navy and had the pleasure of telegraphing Douglas to bring his drawings to Washington to try to work out a design of a torpedo plane. Douglas was given a drafting table in the back room, and some clean government paper and two new government pencils. The Navy got a torpedo plane and the Army got a bomber, and from it the credit for the first flight around the world.

The rest of the Donald Douglas story is the reason the Guggenheim Medal is awarded to him tonight. He has created the air transport industry by means of a vehicle that was safe, fast and economical, just as he was fundamentally responsible for the first round the world flight.

Dr. Hunsaker then presented the award to Mr. Donald Douglas.

Mr. Donald W. Douglas

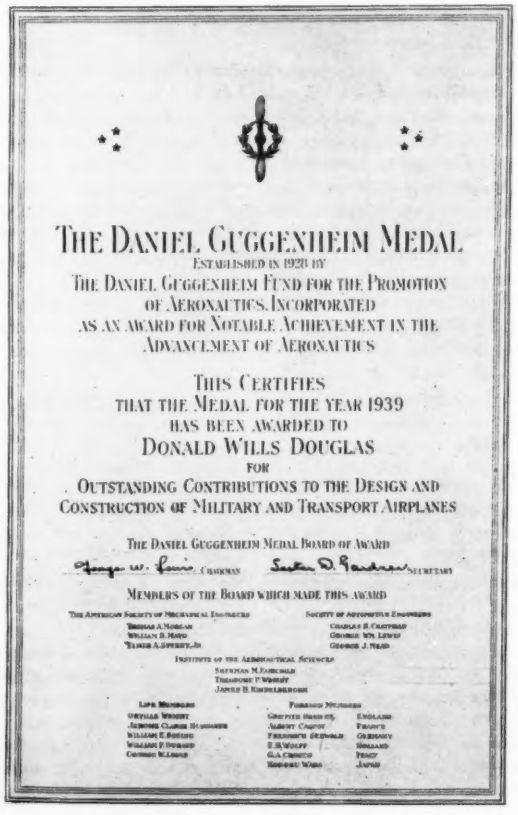
I am grateful for the high honor you have conferred upon me and keenly aware that I can accept it only as a custodian for the countless brave and able men whose endless efforts, vision, and courage have made aviation what it is today.

We have traveled far and fast from that historic December day at Kitty Hawk.

That inspiring journey of aviation to its present position in our lives and destinies has not been made without sacrifice. Triumphs and tragedies, rewards and ruin, success and failure, are some of the milestones in its upward swing.

We still have far to go and much to do. Ours is a task that never ends.

I think it is timely and proper that we pause to pay tribute to our co-workers, living and dead, who cleared the way that



THE DANIEL GUGGENHEIM MEDAL

ESTABLISHED IN 1928 BY
THE DANIEL GUGGENHEIM FUND FOR THE PROMOTION
OF AERONAUTICS, INCORPORATED
AS AN AWARD FOR NOTABLE ACHIEVEMENT IN THE
ADVANCEMENT OF AERONAUTICS

THIS CERTIFIES
THAT THE MEDAL FOR THE YEAR 1939
HAS BEEN AWARDED TO
DONALD WILLS DOUGLAS
FOR
OUTSTANDING CONTRIBUTIONS TO THE DESIGN AND
CONSTRUCTION OF MILITARY AND TRANSPORT AIRPLANES

THE DANIEL GUGGENHEIM MEDAL BOARD OF AWARD

Orville Wright, CHAIRMAN Lester D. Gardner, SECRETARY

MEMBERS OF THE BOARD WHICH MADE THIS AWARD

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
Thomas A. Morgan
William B. Mayo
Elmer A. Sperry, Jr.

SOCIETY OF AUTOMOTIVE ENGINEERS
Charles B. Chayne
George Wm. Lewis
George J. Mead

INSTITUTE OF THE AERONAUTICAL SCIENCES
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Kotaro Wada, JAPAN

others might follow. Theirs was a contribution of fundamentals. They reached out into the unknown, explored the hidden recesses of science and often ventured beyond the horizons of safety. They gave us the fixed points and the building blocks on which our accomplishments rest. To them, and to the thousands of craftsmen and engineers, dynamic dreamers of the drawing board, and skilled mechanics in our own plants, and in scores of aircraft factories in our great land, I pay my respects. With them I proudly share the honor you have so generously bestowed upon me.

Where does the highway of aviation lead humanity? Is its course true? For all its wonders and conquests over nature, does it lead us forward or backward in civilization and in humanitarian objectives? Time alone can give the final answer. Tonight I wish I knew. I am not a prophet or a philosopher. I am only an engineer.

I know no formulas by which to tell a defensive airplane from one used in offense. Our tables deal with mathematics, not motives. In a world so full of conflict and confusion the greatest discoveries and gifts of science become slaves and servants, not always on the side of right and justice. The laws of gravity and aerodynamics recognize no distinctions between the aggressor and the victim. The dictator and defender share alike in the triumphs of science. Let the historian, unhurried by cataclysmic events, and blinded not by heat and passions of contemporary tragedies, deal with these problems. Time and history will tell the tale. But in the telling they will have to record that man-made things played a deciding part in the great drama of our times; that American aviation kept pace with progress, and that the aircraft industry did not lag in its own country's national defense. Of this I am certain. Alert and efficient, young but vigorous, the aircraft industry will present to the historian of the future, as it does to the nation today, a strong united front, come what may.

I have great faith in the future of aviation as a constructive servant of mankind. I raise these questions because eventually aviation will justify the hopes and faith of those who pray and long for peace.

In the face of the wartime boom, in spite of war, conflict, and destruction, I have faith in aviation's path and ultimate destination. I know that war—AND DEFENSE—are not the only travelers on that highway. I take courage in the fact the aircraft factories in the United States today show the largest back-logs of commercial airplane orders in the history of aviation, that thousands of craftsmen and engineers are building wings for peace-time pursuits, that thousands of able, courageous men are striving to make commercial flying safer and more economical, and that commercial airlines in this and in other countries are expanding and planning for the future.

I know that greater, more luxurious airplanes of tomorrow are being designed and constructed. I know that everywhere plans for the future are dominated by things to come. Engrossed with war and its implications, the aircraft manufacturers of America are not forgetting progress for peace. Subject only to the demands of our government and national defense, our eyes and energies are fixed on the wide oceans that must be spanned by air, and on distant continents patiently awaiting aerial commerce.

Against such an inspiring background the "contributions to the design and construction of transport airplanes," recognized here tonight, gain in importance and value. The honor and recognition for this achievement must be credited in a large measure to the traditions, accomplishments, and spirit of the entire Douglas organization. From Arthur E. Raymond, Director of Engineering, to the youngest draftsman; from Carl A. Cover, our General Manager, to our newest employee came and will continue to come efforts to improve the transport airplane of today.

It is with this knowledge and with a heartfelt salute to them and to men everywhere who plan, build, and go up in the sky in aerial ships of good will that I accept the Guggenheim Medal and pledge myself and my organization to further service.

Presentation of The Sylvanus Albert Reed Award

Dr. Lewis

Dr. Sylvanus Albert Reed established an award to be named in honor of an ancestor of his who had a famous career in the Revolutionary War. He bequeathed $10,000 as a permanent fund to perpetuate the award and provide an honorarium of $250 each year.

We have asked Rear Admiral John H. Towers, who has known the recipient for many years, to present the award.

Admiral Towers, we are grateful to you too for coming tonight to assist us in honoring an Honorary Fellow of the Institute and one of its earliest Benefactors. General Arnold and Admiral Towers are among the earliest pilots in their respective services. They are held in respect and honor wherever aviation people gather.

We are indeed fortunate to have General Arnold and Admiral Towers directing our military and naval aviation in these critical times.

Rear Admiral J. H. Towers

It is wholly unnecessary to point out to most of this group that the outstanding position attained by the United States in civil and in military aeronautics has been built largely around the development of highly efficient air-cooled radial aircraft engines. Tonight we honor a man who has been a leader in that development from its beginning—a man who is still young but who for many years has been one of the outstanding young men in a young industry. At 28, he was engineer-in-charge of the power plant laboratories of the United States Army Air Corps at what was then McCook Field. Only a few years later he became Chief Engineer of the Wright Aeronautical Corporation. His rapidly expanding interest in engineering and business problems connected with aviation power plants led him in 1925 to take part in the founding of a project at Hartford, which has been the scene of his activities up to the recent past as Vice-President and as Chief Engineer of the Pratt & Whitney aircraft engine organization. He has been responsible for developing the series of Wasp and Hornet engines now in use in civil and military aircraft all over the world. In 1929 he was elected Vice-President of United Aircraft Corporation. In 1925 he was made Vice-President, Director, and Chief Engineer of the United Aircraft group, which includes Pratt & Whitney, Vought-Sikorsky, and Hamilton Standard Propellers. His whole career has been one of rapid and continuous progress in his chosen field.

Dr. George Jackson Mead is a New Englander. He was born in Everett, Massachusetts, 48 years ago. He graduated from Massachusetts Institute of Technology in 1915, and after a tour of duty as an experimental engineer with the old Wright-Martin Aircraft Corporation, launched out on the career that I have described, a road which led him to that position of eminence in the industry for which we are honoring him tonight.

Other well earned honors have come to Dr. Mead in recent years. In 1937 he was invited to lecture before the British Royal Aeronautical Society on "Power Plant Trends." The same year he received the honorary degree of Doctor of Science from Trinity College. He is an Honorary Fellow of the Institute of the Aeronautical Sciences, an Associate Fellow of the Royal Aeronautical Society, a member of the Society of Automotive Engineers, and a member of the American Society of Mechanical Engineers. In 1939, Dr. Mead retired from the Vice-Presidency of United Aircraft, and in October the President of the United

Dr. George J. Mead

States appointed him to serve as a member of the National Advisory Committee for Aeronautics to succeed Dr. Joseph S. Ames, retired. At the following meeting of the National Advisory Committee, Dr. Mead was unanimously elected Vice-Chairman of that distinguished group.

Aviation in America is proud to recognize its debt to Dr. Mead, and I consider it a great privilege to present to him, in the name of the Institute of the Aeronautical Sciences, the Sylvanus Albert Reed Award "for the design and development of high output engines for commercial and military aircraft."

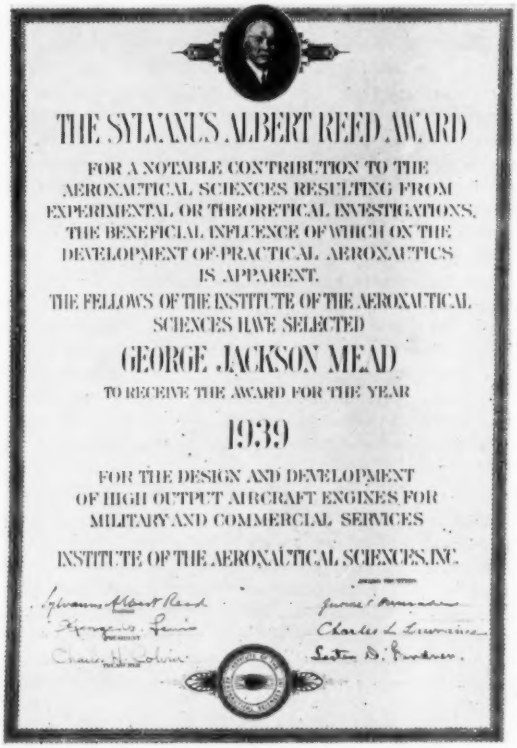
Mr. Latham G. Reed, the brother of Dr. Sylvanus Albert Reed, presented the award to Dr. Mead.

Dr. George J. Mead

I wish to thank Admiral Towers for his most generous remarks and the tribute he has seen fit to pay my work. It is particularly gratifying to know, after more than twenty years' association with the Navy, that the Chief of the Bureau of Aeronautics can commend me so highly. Next, I desire especially to thank Mr. Latham Reed for coming this evening and personally presenting the award founded by his brother which has become one of the greatest honors open to an engineer in the aeronautical field. To the Fellows of the Institute, who have seen fit to confer this honor upon me, I wish to express my sincere appreciation and extend to you, each and every one, my heartfelt thanks. I am proud of the record of American engines, both at home and abroad, and for that reason I am vitally interested in their continued leadership. This will depend upon wise, courageous, and farsighted planning, the necessity for which is more apt to be lost sight of with plants running to capacity than when competition is rife. Nevertheless, constant thought and work along these lines are essential if the selfsame facilities are to furnish the outstanding engines of tomorrow.

The success of commercial aviation is bound up with economies of operation, while our national defense depends more and more on superior plane performance. The future development of our aeronautical power plants then becomes of vital importance. The problems incident to the design and refinement of larger and more powerful units are becoming increasingly difficult, with the result that four to five years are required to develop thoroughly a new type, adequately service-test it, and put it to work in reasonable quantities. The engineering and development expense may easily run from a million to two million dollars a year. Even the original Wasp engine of 400 hp., the first of which was designed and built in five months, required some three years to become firmly established. Price alone will not sell aeronautical equipment upon which the safety of the individual and the nation may depend. The skill of our designers is unexcelled, our manufacturing genius is acknowledged, and we have, in our far-flung airways, the best proving grounds in the world. These assets, despite their importance, may prove of little value unless directed into the proper channels with sufficient foresight. Unfortunately, our countrymen are apt to give the engineer undue credit in believing that he can rise to any emergency, which we know is true only within limits. As a matter of fact, we are forced to rely on what we have in a crisis, as it is impossible in a brief period to make available new engine types of proven value.

Such programs, involving as they do increasingly large expenditures and periods of time, should, of course, be based on the most complete and reliable information possible. The industry, therefore, is justified in plowing back into well-directed experimental and development work a reasonably large percentage of its profits. Fortunately, American executives are beginning to appreciate the value of such an investment, even though the results are not necessarily apparent to begin with. This work frequently provides the knowledge that makes possible the product that keeps the plant going in the years to come and is, therefore, the best possible insurance. Our government should do likewise, only in this case the funds should be used for fundamental investigation. Certain foreign governments have already appreciated the far-reaching significance of aviation, with the result that they have seen the wisdom and necessity of pro-


THE SYLVANUS ALBERT REED AWARD
FOR A NOTABLE CONTRIBUTION TO THE AERONAUTICAL SCIENCES RESULTING FROM EXPERIMENTAL OR THEORETICAL INVESTIGATIONS, THE BENEFICIAL INFLUENCE OF WHICH ON THE DEVELOPMENT OF PRACTICAL AERONAUTICS IS APPARENT.
THE FELLOWS OF THE INSTITUTE OF THE AERONAUTICAL SCIENCES HAVE SELECTED
GEORGE JACKSON MEAD
TO RECEIVE THE AWARD FOR THE YEAR
1939
FOR THE DESIGN AND DEVELOPMENT OF HIGH OUTPUT AIRCRAFT ENGINES FOR MILITARY AND COMMERCIAL SERVICES
INSTITUTE OF THE AERONAUTICAL SCIENCES, INC.

Mr. Charles M. Kearns

viding adequate national research facilities to supplement those of industry. In this country the National Advisory Committee for Aeronautics has done outstanding work in aerodynamics, but as yet we have no comparable facilities devoted to engine research. It has been said that our engines lead the world, which may be true now, but I know only too well what an increasingly difficult task our designers must face unless we too can furnish them the kind of fundamental information that is becoming available abroad.

Our safety as a nation does not so much depend on huge quantities of military equipment produced spasmodically under pressure, but rather on a sufficient uniformity in government orders from year to year to permit maintaining the necessary trained and experienced engineering and manufacturing staffs at the various industrial plants. These men can be relied upon to produce better and better prototype equipment, from year to year, under the stimulation of active competition, and thus put the industry in a position to supply almost any quantity of really outstanding equipment whenever it is required. We now have an opportunity to firmly establish ourselves in such a position and for this reason I wish to stress again the need for long-range planning, more and more fundamental research, and a greater uniformity in procurement to stabilize the industry.

Nobody realizes better than I what a small share one person can have in the development of a modern power plant, involving, as it does, so much diversified and highly technical work. I therefore desire, at this time, to pay sincere and well deserved tribute to the host of loyal workers who have made possible whatever success you may attribute to me.

Presentation of the Lawrence Sperry Award

Dr. Lewis

The next award we present was endowed in memory of a young man who made a great name for himself in the early days of flying. His brothers and sister have set up a fund to permit the Institute to give to a young man under thirty years of age a certificate and honorarium of $250 for notable contributions to the advancement of aeronautics.

This year the award is made in the field of vibration engineering and we have asked one of the leaders in this specialty, Professor J. P. Den Hartog of Harvard University, to tell about the work of the recipient.

Prof. J. P. Den Hartog

Charles Kearns is to receive tonight the Lawrence Sperry Award of the Institute "for the successful application of methods of measuring propeller vibrations in flight." As most of you know, he does it by gluing to the propeller blade a small strip of carbon, which during the vibration follows the strain variations of the blade. The corresponding electrical resistance variations of the carbon are then amplified and recorded by an oscillograph. As is the case with most significant developments, there is a history behind it of several men, who all contributed to it, but one man finally took the all-important step which assured success.

The problem consists of measuring stresses in the centrifugal field of a propeller, which is almost 10,000 times that of gravity so that the pickup must have practically no weight at all. The first useful device for this purpose was the so-called scratch-gage of Professor deForest, which solved the problem of measuring the magnitude of the stress, but not as yet its frequency.

In 1933, a student named A. Bloch, writing a Doctor's thesis in Munich, Germany, on impact stresses in railroad tracks, had difficulty with existing stress meters. He left the country of his birth and found asylum in Ireland, where, at the University of Dublin, he experimented further, and among other things painted the rail with a carbon paint. In the August 10, 1935, issue of "Nature" he published a short note, stating that with a two-stage amplifier the paint worked well for impact stresses. This

THE LAWRENCE SPERRY AWARD
FOR A NOTABLE CONTRIBUTION MADE BY A YOUNG MAN TO THE ADVANCEMENT OF AERONAUTICS
THE BOARD OF AWARD HAS SELECTED
CHARLES MAXWELL KEARNS JR.
TO RECEIVE THE AWARD FOR THE YEAR 1939
FOR THE SUCCESSFUL APPLICATION OF METHODS OF MEASURING PROPELLER VIBRATION STRESSES IN FLIGHT
BOARD OF AWARD
INSTITUTE OF THE AERONAUTICAL SCIENCES
Secretary
President

article was read in Schenectady by E. H. Hull of the General Electric Research Laboratory, who repeated the experiments and improved the electric circuit.

In January, 1936, Dr. Hunsaker visited Mr. Hull's laboratory, realized the importance of the setup and told Messrs. Caldwell and Martin about it. They went to Schenectady, saw the experiment, and had development work started at the propeller plant at Hartford.

Six months later, in June, 1936, Charles Kearns became a B.S. in Electrical Engineering at Pennsylvania State College, and began work with the Hamilton Standard Propeller Company. He did not lose much time in commencing, either, because on the 14th of August he conceived the idea for which he stands honored tonight. The trouble with the carbon paint was that there exists no possibility of calibrating it. It will give as nice a picture on the oscillograph film as the present technique, but there is no way of stating how many pounds per square inch the record means. He replaced the paint by a solid strip of carbon and developed means whereby these strips could be glued to and removed from a specimen many times over. By putting the carbon strip on a calibration bar and then attaching it to the propeller afterward, the problem is completely solved in a convenient way. Since then Kearns and the men who are working with him have made new amplifiers and other auxiliary gadgets with the result that at present they can take as many as 50 simultaneous stress records if need be.

The importance of this development is obvious. The stresses in propellers and other parts can now be tested accurately in the course of a day or so, and the effect of changes in the construction can be checked. Now we know exactly where we stand with a propeller, whereas before Kearns' work we were blindfolded or, at best, could see through the glasses of theory only.

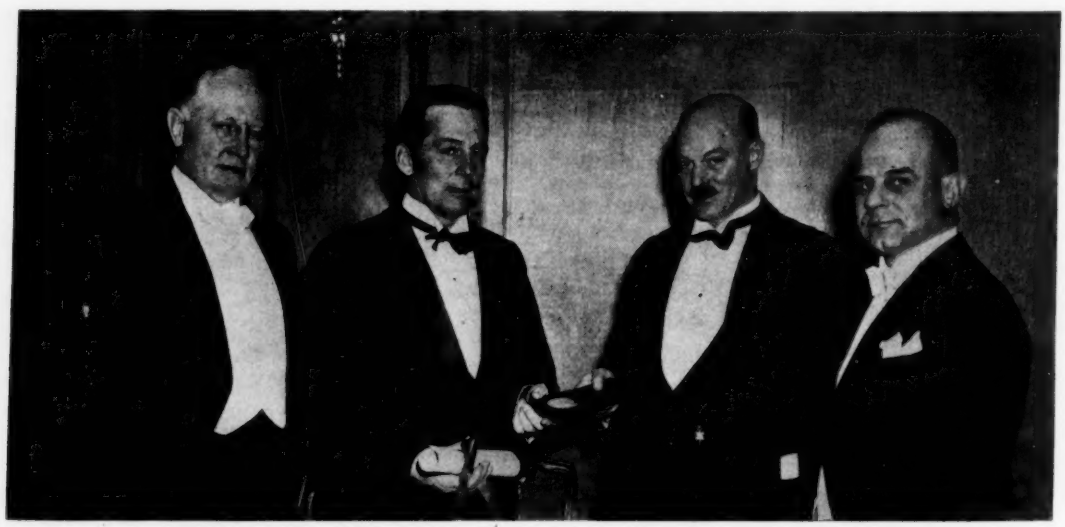
It is most appropriate that a young man should present another young man with an award for young men. Charles Kearns is 25 years old. When Lawrence Sperry was the same age in 1917, he had successfully developed what later became known as the "automatic pilot." He had won in open competition with all comers a prize offered by the French government for a safe airplane. It is therefore particularly fitting that the award established in his honor can be presented by his son, Lawrence Sperry, Jr.

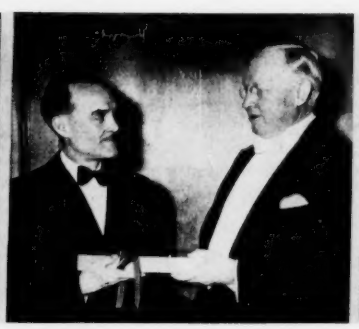
Mr. Lawrence Sperry, Jr., son of Lawrence Sperry, to whose memory the award is dedicated, presented the award to Mr. Kearns.

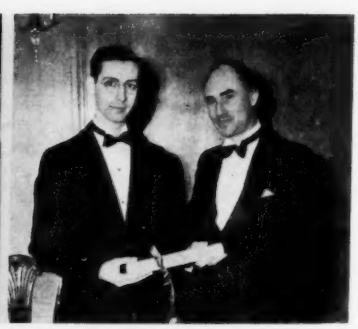
Mr. Charles M. Kearns

I am deeply grateful for the unexpected privilege of being here tonight to receive the coveted Sperry Award.

In accepting this honor I feel obliged to point out how small my







Top: Dr. George W. Lewis, Dr. Donald W. Douglas, Dr. J. C. Hunsaker, Major James H. Doolittle; Dr. Hunsaker is presenting the Daniel Guggenheim Medal to Mr. Douglas (*Wide World photo*). Bottom: Mr. Latham Reed presenting the Sylvanus Albert Reed Award to Dr. George J. Mead (*Wide World photo*); Dr. George W. Lewis presenting the Octave Chanute Award to Mr. Edmund T. Allen (*Wide World photo*); Prof. J. P. Den Hartog presenting the Lawrence Sperry Award to Mr. Charles M. Kearns (*Pictures, Inc., photo*).

own contribution was to the subject for which the citation was made. This can perhaps best be done by mentioning the names of some of the men active in this work.

I am especially indebted to Mr. Ralph Guerke for his advice and help in the development of the strain gage, as well as to Professor A. V. deForest for his helpful suggestions. As Dr. Den Hartog pointed out, the whole industry is indebted to the General Electric Company for their initial suggestions.

It is of interest that the instruments which were first adapted to propeller stress measurements were manufactured by the Sperry Gyroscope Company after being developed by Dr. C. S. Draper.

To Dr. Den Hartog, Mr. Frank Caldwell, and Mr. Erle Martin I am permanently indebted for their kind advice and continued inspiration.

It is, therefore, in the name of all those men who continue to strive to improve the safety of aircraft propellers that I accept this award.

Presentation of Honorary Memberships and Fellowships

Dr. Lewis

And now we come to the part of our program when we extend honors within the membership of the Institute. We have a self-expanding group of Fellows. From the beginning the Institute has placed the responsibility of electing Fellows on the Fellows themselves. Only ten may be elected each year and the honor of being chosen by over eighty of the leaders in American aeronautics is coming to be regarded as admission to one of the most carefully selected groups in scientific circles. We also give honors for outstanding contributions to aeronautics with Honorary Membership in the Institute. Those so honored this year are: Hon. Robert H. Hinckley, Chairman, Civil Aeronautics Authority; Rear Admiral John H. Towers, Chief, Bureau of Aeronautics, U.S. Navy Department.

In the President's Annual Report, I have given the names of the new Fellows and Honorary Fellows. I am glad to present certificates to those who are present at this dinner.

Induction of New President of the Institute

Dr. Lewis

I am now at the end of my duties as your President. I have enjoyed the privilege of serving you. I have made many new and helpful friends. I have learned to appreciate better the work of my predecessors. I thank all the members of the Council, the officers, and the Institute staff for the help they have given me during the past year.

You are to have as President next year one of the foremost figures in American aviation. He is one of those rare combinations—a great pilot and a trained engineer. No one receives the degrees Master of Science and Doctor of Science from the Massachusetts Institute of Technology without being worthy of the highest recognition. He holds the Distinguished Flying Cross for his work in the Air Corps. He was the first man in the world to make a blind landing and make an outside loop in an airplane. He has won many races and established many records. The world knows him as a great pilot but we know him as a great engineer—one who can sit at the controls of the Institute as ably as he can at those of an airplane.

It is a particularly great pleasure for me to step down from the President's cockpit and yield it to a man who by experience, courage, and ability is so well fitted to carry forward the work of the Institute for 1940.

Major James H. Doolittle, newly elected President, I.Ae.S.

Major James H. Doolittle

Dr. Lewis: I appreciate the generous way in which you have presented me as your successor as President of the Institute of the Aeronautical Sciences. It will be difficult for me to follow such distinguished and able presidents as the Institute has had. You and your predecessors have created a society which is highly respected wherever aeronautics is considered; and that pretty well covers the globe. The Journal, which Dr. Hunsaker has so ably edited for the past six years, is one of the foremost scientific aeronautical magazines. The fact that the Institute now has a membership of almost three thousand, and the splendid attendance at this Annual Dinner, are further indications of the soundness of the policies established and followed.

I appreciate more than I can express in words, the honor that was done me in choosing me to carry on the work of the Institute. Frankly, as I have told the Council, in being elected President of the Institute of the Aeronautical Sciences I feel that I have received the highest honor that it is possible for American Aviation to bestow.

I am fortunate in knowing many of our American members and some few of our famous foreign members, and appreciate how great are the contributions they have made to the advancement of aviation here and abroad, and, consequently, fully appreciate the responsibility that one accepts in undertaking to maintain the high standards that have been set.

I shall earnestly strive to serve the Institute to the best of my ability. The Aeronautical Archives will broaden the service the Institute can render its members and the public. I shall be the beneficiary of the increased scope of our work and wish to join Dr. Lewis in expressing my appreciation to Mr. Burden for his great generosity in loaning his priceless collection to the Archives. His selection of the Institute as the organization which he believed best able to use this extensive collection for the greatest good to aeronautics is a compliment which we will have to live up to by making it one of the greatest and more useful centers of aeronautical information in the world. A friend of the Institute,

well known to all of us, heard of Mr. Burden's plan and immediately offered to give a collection of valuable papers and relics that he has been collecting for twenty years. The formal announcement of this gift will be made when the Archives are dedicated.

A few years ago, civil aviation was in the doldrums. There was no certainty about anything except losses. When the Civil Aeronautics Authority was authorized by Congress the change was greeted with enthusiasm. Then came the trying period of organizing a new government agency. Soon, however, the C.A.A. commenced to function, and you all know of the great effort they are making to encourage and advance all forms of civil aviation. Our guest speaker was unknown to most of us three years ago. And most of us were unknown to him. We got acquainted and apparently it was love at first sight on both sides. His great ability and far-seeing plans won our confidence. His cordiality won our admiration. He accepted us as friends. We hope that we will not only merit his regard, but will show our everlasting gratitude for his great achievements.

I am happy to present to you the Chairman of the group that is leading American aviation to the Promised Land—the land of our dreams—Robert H. Hinckley, Chairman of the Civil Aeronautics Authority.

Government in Aviation

Hon. Robert H. Hinckley

Every time I see a great airliner in port or in flight I think of it as the end product of thousands of hours of painstaking work in scientific laboratories. The curve of the wings, the N.A.C.A. cowling, the adjustable pitch propeller, the delicate yet dependable instruments filling the panel, the lightness and strength of the metal covering and internal structure. I think, too, of the marvelous efficiency of the motors and of the high octane fuels, of the quality of lubricants, of the radio system and of the passenger comfort. But never do I forget that the place of origin of this modern miracle was Kitty Hawk, North Carolina, and that the original creators were two brothers who knew how to use the scientific method. Neither do I forget that you meet each year to report new discoveries and thus honor the men who closed an age-old debate on December 17th, thirty-six years ago. They proved that men could fly. Their achievement was one of those revolutionary scientific demonstrations that smash centuries of so-called "hard headed" logic.

I want to talk to you as business men and as citizens, rather than as scientists. You *are* business men, in the sense that your own work depends, broadly, upon the welfare of the business of aviation. I have been a business man much longer than I have been a government official. But my brief public experience has been a revelation to me, showing me problems in public administration that I never dreamed of in my own business.

You run into the No Man's Land of Science where there are no objective yardsticks, where human opinions and human emotions color every judgment. For example, how far shall we carry government assistance to aviation? How far centralized control? At what point shall we abridge the rights of the individual flyer for the sake of the public? Shall we also abridge his flying freedom to protect him against *himself?* Shall we set up rigid standards both for airline pilots and airline equipment, or how far shall we trust private industry? What is our obligation toward operators who come running to us with minor problems and ask us to regulate, regulate, regulate? How far shall we go to eliminate competition? What is wasteful competition? What is the regulatory relationship between the Federal government and the various states? Shall we promote airports and trust the planes to follow, or promote planes and trust the airports to follow, or both, and how much of each? Right now we have the problem of determining how much the larger airports of the country, where many scheduled airliners land, are to be restricted so far as their use by private owners and small commercial operators is concerned.

We all pay something for every blessing we enjoy; and we pay for democracy by wide-open discussion and wide-open handling of the public business. We have our own crystal-clear way of meeting our problems. If we want, for example, a continuing permanent policy in aviation, all we have to do is to demonstrate the public desirability of that policy.

We can fairly assume that the Civil Aeronautics Authority has as cordial and cooperative a relationship with the industry it supervises as any federal agency has in its respective field. The Civil Aeronautics Authority is only 18 months old, so that everybody still can remember clearly how and why it was created. We all remember that aviation awoke one morning to the realization that it was in a desperate condition. "Chaotic," is the way a Congressional committee described it. Unbridled, ruinous competition had frightened off investors and ruined many operators. Government services to the industry were scattered in small segments through numerous unrelated federal agencies. And so aviation requested one central authority with which it could deal. The Civil Aeronautics Authority was that authority.

Since that time we have had to plot and travel a new course somewhere between old-fashioned, dog-eat-dog, laissez-faire competition and the other extreme of absolute monopoly. We have had to guide and service the fastest-growing public utility the country has ever known in a way that would maintain competition and private initiative. Nobody could give us a formula for that, and it's a big order. The industry itself should remember that.

I don't mean the industry should not criticize. Constructive criticism is good medicine for governmental bureaus. Bureaus have an inevitable tendency to grow smug. Their officials tend to lose their sense of responsibility to the public—to feel they know more than those with whom they deal—to resent being questioned.

Only a short time ago a well known political figure without any knowledge of scientific matters advised the President of the United States that certain governmental agencies had only ornamental use. Among these governmental agencies he included the National Advisory Committee for Aeronautics. Yet, I am sure that an objective study of the evidence would show that, for every dollar expended by the Government through the National Advisory Committee for Aeronautics, many dollars were returned in cash dividends.

I do not know to what extent the Institute of Aeronautical Sciences will extend its field to include the problems which we might classify under the general heading of "Human Behavior." I know that the solution of such problems is very difficult. I know that the units of measurement in these fields are few and that the methods for making such measurements are being developed. But that is no reason for ignoring them, and I note with commendation that you have on your program workers in the field of medicine. These workers play a very important part in aviation, although they may not have developed as many formulas or units of measurement or exact methods of measurement as are needed in that field. Every field you conquer means fewer headaches for administrators.

By saying that we welcome criticism and want a great many people to express themselves, I do not mean that we want to pass a lot of rules. *We do not want to pass a single regulation that is not absolutely necessary.* We recognize that a pioneering activity such as aviation needs especially to be left free from over-regulation. Our concept of the situation is that we should hear everybody concerned, and gather very complete evidence; but that the Civil Aeronautics Authority's working relationship with the industry—particularly since the whole field is new—should be

kept as fluid as possible, with mandatory regulation at a minimum.

Another point. Just as we would like to keep the industry as free from excess regulation as possible, we also would like to avoid the creation of new governmental machinery to do work that can be done just as well—and often perhaps better—by private facilities.

Of course the Civil Aeronautics Authority has to take the lead. One of our biggest problems right now is how much of our authority we can properly delegate, and it's another of those fields of pure opinion. We are working on it, along with numerous other problems such as, shall we subsidize feeder lines, shall we promote safe-type aircraft, and what is our relationship with aviation authorities of the various states.

I believe we all will agree that one of the basically important things to the industry is the number of people who own and fly aircraft. Several months ago I asked our people a few questions in this field, and I was startled to learn that nobody ever had compiled the answers. The great achievements of the commercial carriers give us in general a pretty rosy picture over the last couple of years, and it is something of a jolt to make such a simple inquiry in the private field and draw a blank.

Our people have done some rather elementary research since that time, and I want to tell you about it. We made a cross-section study of the private ownership of airplanes in this country during the past eight years. We found that the average life of a private airplane was six years. But we made the *very* unpleasant discovery that the life of an airplane *owner, as* an owner, was far shorter than the life of his first plane!

In short, four out of five of all those who bought their first planes during this period had got rid of them within a mean period of two and one-half years, and had *not* bought others. Over half had disposed of them in two years, and one-third had got out of the ownership field in *one year*.

Let's put it another way. Approximately fifteen thousand new non-commercial owners bought airplanes during the years 1931 to 1936, inclusive. Yet so many dropped out that the net total increase in private owners for the same period was less than 300. Less than 20 percent of airplane purchasers continued their ownership longer than the seven-year period of the study.

The "mortality" of ownerships is so great today that 2900 new owners must be found each year to maintain the present total without increase.

What is the answer? We don't know. Aviation as a whole must diagnose this trouble, and cure it. We hope that all of you will go to work on it with us.

One thing we already have done, of course, is to arrange for the training of thousands of new civilian pilots. We feel certain that if you create a great many new flyers you are going to produce, inevitably, a considerable number of new owners.

I have been speaking in general terms about our problems and policies. Perhaps if I tell you the story of the Civilian Pilot Training Program I can apply these policies specifically.

It seemed desirable to develop civilian facilities, including pilots and civil aircraft factories, as a defense measure; and at the same time to advance use of the airplane and knowledge about the airplane through civilian activities. If by any happy chance we do not have to defend ourselves, there will be nothing but profit, because the expansion of our civilian facilities is long overdue.

How did we go about meeting these two problems? First, we prepared a plan of action within our own organization. Then we discussed it with state aviation officials, with officials of our educational systems, including the Office of Education, with the operators of private commercial schools and the builders of civil aircraft. We did not forget the Army and Navy, because our defense services have had years of experience with pilot training. Naturally, our original plan was considerably altered as the result of the advice we got from all these interested groups. We wanted that advice. That is the policy of using the consensus of interested viewpoints, where we have no formula.

But in order to test it out, we obtained from the National Youth Administration $100,000 to conduct a group of experimental courses at 13 colleges in various parts of the country. Three hundred and thirty students were enrolled, of whom 97 percent finished their training and received certificates of a private pilot grade.

Following the completion of the experimental course, we called in the operators of the commercial schools who had been conducting the flight training, and the college officials who had been directing the ground schools. We obtained from both groups valuable suggestions for the improvement of our original plan.

As a result of this careful preparation, we were able to go before Congressional and Senatorial committees and present objective evidence of the desirability and workability of a much larger program. This program is now being carried on in 437 colleges and universities throughout the country and the territorial possessions. That is the policy of using the nearest thing to a scientific approach that was immediately available.

Congress wisely provided that at least five percent of those we train in this larger program should come from non-college young people. We have met this requirement by arranging for the training of 700 young people, or approximately seven percent of the total to be trained, by commercial operators and to be supervised largely by local committees of interested citizens.

What has been the response of students to this opportunity? There is enough money in this program to permit 10,000 young people to learn to fly this year. Each of those who qualify for flight training has to put up a $40 fee of his own money. Yet the 437 colleges and the 75 non-college stations were literally swamped with applicants. We do not know what the total of applications was, but we are confident that if we had had the facilities, it would have been no trouble at all to enroll 50,000 young people. In one university, there were 1200 applications for a quota of 30 places in the course.

The demand did not stop there. When we started ground schools for those who had qualified, 3000 additional college students enrolled and started ground training, even when assured they cannot have flight instruction this year. These 3000 are being carried by the universities and by their own funds, without cost to us.

The situation in the non-college group is even more startling. Here, it now appears, at least 10,000 applicants between 18 and 25 years of age will pay ten dollars each for the privilege of taking a ground course and competing for 700 places in the flying course. They are doing this with their eyes open to the fact that 93 percent of them will have to fail.

The authority did not hesitate to tackle the job, did not play safe in fear of failure. It obtained the advice of all the interested groups in the field of aviation and education instead of depending on the decision of a few agency officials. It reached out to educational and flight training institutions where facilities were already set up, instead of creating bureaucratic units of its own that it could supervise with an iron hand, without interference from anyone else. In short, it has largely delegated to local groups with existing facilities the task of carrying out a new enterprise to meet a public demand.

The same policies have been followed in our pilot selection research program. This enterprise has been turned over to the National Research Council, an agency of the National Academy of Sciences. The National Research Council was originally set up by President Lincoln and reorganized under President Wilson, to serve the Government in research whenever requested. A distinguished committee of scientific men has been appointed by the Council to give direction and advice to workers in university laboratories who will conduct researches on problems of selection and training of pilots. Thus the existing facilities in many of our best universities have been made available to us.

It seems to me that a scientist has a greater responsibility than the average man. He may be making life fuller and richer for all of us in the long run, but in the meantime he is making it more and more complex by providing strange new mechanisms that only time will show us how to use wisely.

That is why I have tried to take you into my office and let you see the parade of the problems for which we have no formulas. There is, of course, a better way, if only it could be done. That would be for each of you to spend a little time in government service and get this story first-hand. I think it might be of benefit to you, and I *know* it would be of great benefit to the country.

Following the speaking program of the dinner, members and guests had the opportunity to see the first public showing of the motion picture, "The Conquest of the Air," which was shown through the courtesy of Films, Inc. Starting with man's earliest attempts to fly, the picture shows short views of many of the memorable flights of aviation history, the development of air transport and concludes with a tribute to the military and naval air services. Except for the earlier sequences, the film is composed entirely of authentic documentary material dating back to the earliest years of the motion picture camera.

Book Reviews

Aircraft Blueprint Reading, by H. V. ALMEN and R. K. MEAD; Pitman Publishing Corporation, New York, 1940, 124 pages, $1.00.

This book is intended primarily as a textbook on the reading of aircraft blueprints by students of the mechanical arts involved in the aircraft industry; it is not intended for and would not serve as a course in mechanical drafting. The subject matter is presented by means of sample prints and a complete explanation of the information which they furnish and how it is conveyed.

After an excellent general discussion of 30 pages, the remaining 90 pages are given over to machined parts details, sheet metal and formed parts details, assembly details, the use of dash numbers, major assembly blueprints, and schematic diagrams. Problems at the end of each chapter help to make the work suitable for a text. Numerous examples are worked out in the text and at the end is a list of problems to be solved by the student.

The Oil Engine Manual; Temple Press, Ltd., London, 1939; 368 pages, 5s.

This manual, written by the technical staff of "The Oil Engine," is a well-written, profusely illustrated account of the development, description of the operation, and types of oil engines.

Part I starts with an historical account of the development of the oil engine. There follow chapters on working principles, injection, ignition, and combustion, starting systems, pressure charging, lubrication, and maintenance.

Parts II and III treat all types of industrial and transport oil engines, giving brief descriptions of each.

One chapter on aircraft engines describes the Beardmore "Tornado," Bristol "Phoenix," Coatalen, Clerget, Deschamps, Jalbert, Junkers-Jumo, Mercedes-Benz, and Packard Diesel engines. A bright future for Diesel engines in the aircraft field is predicted.

The current practice and past development of the oil engine are well described. Those who are interested in Diesel engines will find much valuable material in the book.

Ripper's Heat Engines, revised by A. T. J. KERSEY; Longmans, Green and Co., New York, 1939; 336 pages, $1.60.

The original edition of this book is probably better known abroad than it is in the United States. Mr. Kersey is to be congratulated on an excellent revision. Starting from fundamental physical principles the functioning of all types of heat engines is clearly described. The final chapter is devoted to internal combustion engines. There are many excellent illustrations.

From Crate to Clipper, by WILLIAM S. GROOCH; Longmans, Green and Company, New York, 1939; 243 pages, $2.00.

The career of Ed Musick is typical of many of the older pilots of American commercial airlines. Starting as an automobile mechanic he and a few friends built their own plane of miscellaneous parts, and spent their savings learning to fly. Musick became a stunt pilot and gained his first recognition as an exhibition flyer. This naturally led to his many years as an instructor for commercial air schools, the Marine Corps, and the Navy. He was one of the earliest air mail pilots and then became interested in flying around the Carribean. After joining Pan American he pioneered practically all of their new routes.

His friend and associate, W. S. Grooch, has written a vivid story of his life, in which he reveals more of the personal qualities than is usual in such biographies.

The author was killed in an airplane accident in Mexico on November 13th. He was engaged in the installation of new airlines in the Mexican High Sierras.

Pilot's Summer, by F. D. TREDREY; Gerald Duckworth & Company, Ltd., 1939; 236 pages, 8s. 6d.

There is no royal road to becoming a flying instructor in the Royal Air Force. No matter how many hours a man has had in the air and how great his experience has been he is required to take the flying course and to memorize the standardized "patter" of the Central Flying School. While a student the author kept a diary in which he not only recorded the memory courses he had to learn, to give flying instruction according to the approved methods, but, in addition, preserved an interesting picture of the life at an R.A.F. aerodrome and of a service pilot when off duty.

At a time when so many thousands of young men are taking flying instruction this book will be helpful in showing them how carefully their instructors are trained and why they are required to follow a prescribed technique. With great skill Tredrey gives the essentials of the course. Amusing anecdotes and experiences make an interesting story out of what might have been just another series of flying lessons.

High spots are the amusing description of a visit to a military outfitter who attempts to sell the prospective officer everything he will and will not need, and the odd complaints made to mess officers and their pungent replies.

The Aeronautical Archives of the Institute of the Aeronautical Sciences

The founding of what will become the most comprehensive aeronautical archives in the world was announced at the Annual Meeting of the Institute by Dr. George W. Lewis, retiring President. This was made possible by the loan by W. A. M. Burden of his collection of about ten thousand aeronautical books, magazines, photographs, reports, and clippings, which form the most complete privately owned aeronautical library in this country. To this will be added the extensive technical library of the Institute and the Aeronautical Index consisting of over two million references, which has been in the process of preparation for four years under a grant from the Works Projects Administration. Fifty thousand clippings, known as the Phillips Collection, were purchased by Mr. Burden and presented to the Archives to be added to the biographical files, making them, it is believed, the most extensive in the world. A collection of models of airplanes which have been presented to the Institute as well as many interesting relics of great flights will also be included and will form the basis of a small but interesting aeronautical museum. Two great aeronautical collections of historical importance, containing photographs, prints, airmail stamps and covers, medallions, and trophies and relics of great flights, have been offered to the Archives.

The Archives will be open to the public. Several thousand books will be available soon for the use of sustaining members who cannot visit the Archives in New York. A catalogue of these books will be available shortly. A monthly bulletin will keep members informed as to the current aeronautical publications. Experienced personnel will be available to do research work for those who wish such service.

Visitors to the Archives will find many of the rarest aeronautical books, as well as a most complete technical reference library. They can read the first book written by an American on aeronautics, the account of the first crossing of the English Channel by air by Dr. John Jeffries of Boston who financed the balloonist Blanchard and made the trip with him. They will find the early American aeronautical books by John Wise, Octave Chanute, and the first American periodical, *The Aeronautical Annual* published by James Means in Boston in 1894–96. The most beautifully illustrated books on aviation will also be available.

Major Lester D. Gardner is President of The Aeronautical Archives, which will be located in Rockefeller Center adjoining the offices of the Institute. Its Secretary is Elmer A. Sperry, Jr., and Charles H. Colvin is Treasurer. Mr. W. A. M. Burden, of National Aviation, is Chairman of a Board of Directors, which represents many aeronautical activities. The Directors are:

Mr. W. A. M. Burden

Thomas H. Beck, President, Crowell-Collier Publishing Corporation; James H. Doolittle, President, Institute of the Aeronautical Sciences; Donald W. Douglas, President, Douglas Aircraft Company, Santa Monica, California; Sherman M. Fairchild, President, Fairchild Engine & Airplane Corporation; R. H. Fleet, President, Consolidated Aircraft Corporation, San Diego, California; Jack Frye, President, Transcontinental & Western Air; Robert E. Gross, President, Lockheed Aircraft Corporation, Burbank, California; Harry F. Guggenheim; Howard Hughes; Dr. J. C. Hunsaker, Massachusetts Institute of Technology; P. G. Johnson, President, Boeing Aircraft Company, Seattle, Washington; J. H. Kindelberger, President, North American Aviation, Inglewood, California; Grover Loening; Glenn L. Martin, President, Glenn L. Martin Company, Baltimore, Md.; Thomas A. Morgan, President, The Sperry Corp.; W. A. Patterson, President, United Air Lines; E. V. Rickenbacker, President, Eastern Air Lines; Laurance S. Rockefeller; Howard A. Scholle; C. R. Smith, President, American Airlines; Frank A. Tichenor, President, The Aeronautical Digest Publishing Corporation; Guy W. Vaughan, President, Curtiss-Wright Corporation; Edward P. Warner, Civil Aeronautics Authority, Washington, D. C.; Eugene E. Wilson, Senior Vice President, United Aircraft Corp.

Eighth Annual Meeting of the Institute of the Aeronautical Sciences

THE Eighth Annual Meeting of the Institute of the Aeronautical Sciences was held in the Pupin Physics Laboratories of Columbia University at 5:00 p.m. on Wednesday, January 24, 1940. Dr. George W. Lewis presided and C. E. Sinclair was Secretary.

H. J. E. Reid, E. E. Aldrin, and Ralph Upson, tellers, reported that 253 proxies were received in good order.

The Nominating Committee placed in nomination to serve on the Council for three years Charles H. Colvin, Elmer A. Sperry, Jr., Ralph S. Damon, Albert I. Lodwick. Philip B. Taylor and Earl D. Osborn were nominated for terms of one year each on the Council. They were unanimously elected. The following were unanimously elected to serve on the Nominating Committee for 1940: Glenn L. Martin, J. C. Hunsaker, John D. Akerman, T. P. Wright, and C. H. Chatfield.

The following were unanimously elected to serve on the Advisory Board for 1940: John D. Akerman, Harry G. Armstrong, Vincent Bendix, Lyman J. Briggs, Frank W. Caldwell, Jack Frye, Hall L. Hibbard, Philip G. Johnson, C. S. Jones, F. K. Kirsten, Alexander Klemin, Paul Kollsman, Grover Loening, Harold F. Pitcairn, Arthur E. Raymond, M. J. Thompson, J. T. Trippe, E. P. Warner, W. W. Webster, and John E. Younger.

The tellers reported on the balloting on the resolution: RESOLVED, that the Constitution of the Institute of the Aeronautical Sciences, Inc., be amended by deleting from Section 1 of Article 1 the lines "Pilot Members, Industrial Members." The vote was: 213 votes in favor, and 10 opposed.

The President, the Treasurer, and the Secretary, then presented their Annual Reports, which are printed below.

The President's Annual Report

The Institute enters its eighth year with confident expectations that it will be one of the most important in its history. There are four periods in the history of any society. First come the organization years when members are secured, policies are determined and a sound financial basis assured. The second, usually, is acquiring a permanent home. The third is acquiring a great library and the last is securing an adequate endowment. The society which we are proud to recognize as our prototype, the Royal Aeronautical Society of Great Britain, after seventy-four years of distinguished service to aeronautics last year rounded out these four periods; it has a luxurious home, a great endowment of over half a million dollars, a complete library of aeronautical books and a membership which is as distinguished as the history of the society.

Last year we planned to hold an International Congress of the Aeronautical Sciences. Major Gardner and I visited England, France, Germany, Italy and Holland and invited aeronautical specialists to attend the Congress. Many accepted and we looked forward to holding most interesting technical sessions. Unfortunately, we foresaw the possibility of conditions in Europe changing for the worse, and reluctant as we were to do so, we felt that in July we should recommend to the Council that the Congress be postponed for two years or until 1941. We had made elaborate plans for the entertainment of our foreign guests and members. The New York World's Fair 1939 had arranged several events of especial interest to aeronautical engineers and scientists. We are grateful for the cooperation which was offered and hope that by 1941 world conditions may permit our acting as hosts to the postponed Congress.

The second World War and the general disturbed conditions throughout the world which led to the postponement of the Congress has brought to our country many vexing problems, not the least of which is air expansion.

Air expansion on a large scale is now a reality. Increased production demands from the industry, both military and commercial, demands for improved performance, high speeds, longer range for our military airplanes, demands for more efficient, more comfortable airplanes for our transport operators, demands for a reliable, safe and low cost airplane from the private owners' group have presented many problems to our research laboratories and to the aircraft industry.

Now is the time when long range research and effective development methods must prevail in bringing out new airplane and engine types.

We are prepared for this great expansion; the results from our research laboratories definitely indicate that the new demands in performance of military and commercial aircraft can be met. Our aircraft industry has answered the call for increased production without delay. The demands may be even greater for the production of aircraft with more exacting performance requirements which we must be prepared to meet.

I am confident that this can be done and the Institute will do much in aiding this problem by making available scientific and engineering data, correlating effort in the different scientific fields and making itself the important and indispensable factor in our national aviation program.

When the International Congress was postponed, I feared that we might not have an outstanding achievement to point to when I reported to you at this Annual Meeting. But out of the blue sky something so important and unexpected came to us that we have withheld announcing it until today.

Our great index can only tell about people and where their writings and other technical information had been published. We had gathered a small library, but it was entirely inadequate for intensive research. For many years, a member of the Institute has been collecting aeronautical books, prints and magazines, in fact everything he could secure pertaining to aeronautics. He has assembled what is undoubtedly the finest private collection of aeronautical books in the world.

In November Mr. W. A. M. Burden came to us and said that he would be glad to place the greater part of his valuable collection in the custody of the Institute if we were able to maintain it and make its great potential value of real use to our members and the public. It comprises about ten thousand books, pamphlets, magazines, etc. Naturally we were greatly pleased to realize

that another of the four steps in our history could be taken at once and that the Institute could then rank with any scientific society in the world as a source of specialized technical information. Mr. Burden said that he believed that it could render a valuable service if joined to our great index and technical library. After careful consideration, the Council determined to plan for an even broader service—the establishment of The Aeronautical Archives. It will be our aim to secure for it all kinds of interesting material relating to aeronautics and make it useful to present and future aeronautical specialists.

The Institute also appreciates the confidence that has been shown by so many leaders in American aeronautics who have accepted places on the Board of Directors of The Aeronautical Archives. These assure its success and permanence.

I shall give brief summaries of the status of the other activities of the Institute.

Financial. The Treasurer will report a sound condition of our finances. As usual we have only done those things which our budget allowed.

Membership. Our membership has continued to grow as will be seen from the Secretary's report. There has not been as great a growth of Corporate Memberships as we would have wished but we have assurance of wider support this year. We were particularly pleased to have Pan American Airways and the Consolidated Aircraft Corp. join as Corporate Members.

Journal. The subscription price of the Journal of the Aeronautical Sciences has been increased so that it will not continue to be a drain on the Institute finances. Printing and other costs have risen and as the Journal is one of the most expensive types of publication to print owing to the complicated mathematical matter required, it was decided that members and readers would be willing to approve of an increase of from $5 a year to $7.50 a year.

Grading. A change has been made by the Council in the grading of members which I hope the membership will approve at this meeting. The grade of Pilot Member has been combined with the grade of MEMBER so that there will not be as much differentiation as there has been in the past. It has simplified the membership structure of the Institute and received the unanimous approval of the Council.

Dues. Owing to the increased services which the Institute plans to render next year, the Council decided to increase the dues so that they would be more in line with those of similar organizations and assist in maintaining the high standards of the Journal.

Branches. The growth of branches has been steady, particularly at those universities which give instruction in aeronautics. We have provided the branches with lectures which have been given simultaneously. The comments on this service have been most favorable.

Awards. A new award has been established by the Institute in memory of Octave Chanute, one of the great pioneers of American aviation and an engineer distinguished in many other lines. This award will be presented annually "for a notable contribution made by a pilot to the aeronautical sciences."

The Shell Oil Companies of the United States have given the Institute a fund of $15,000 to establish scholarships, prizes, and special recognition awards for Student Pilots who are being trained under the training program of the C.A.A. The awards will be made next Summer so that a fuller report of this activity will more properly come in the report of the President next year. I wish to thank the Shell Oil Companies on behalf of the Institute for their generous action in making it possible for the Institute to give rewards for special excellence to some of the best of the thousands of students who are taking this training. It will be an incentive which will have most beneficial results.

Meetings. As the Institute had planned to concentrate its meeting activities at the International Congress of the Aeronautical Sciences there have not been as many papers read at our meeting as in the past. As this was unavoidable we must accept it as a part of the changing conditions of last year.

Aeronautical Index and Bibliographical Files. The Works Projects Administration has continued to provide workers and material for the increase in the aeronautical files of the Institute. So that they could be more widely used there have been published 47 bibliographies on various subjects comprising technical aeronautics. About ninety workers have been kept busy searching for new information, compiling and transcribing it and then putting it in printed and bound form. The letters of appreciation received from all parts of the world as well as from universities, governmental departments and libraries let us know how greatly this work is appreciated. Again we thank the Works Projects Administration for their continuing support. It has been a fine contribution to the advancement of the aeronautical sciences and is so recognized by scientific workers in this country and abroad.

The Library. The growth of the Institute's library has progressed so rapidly during the year that it is becoming a serviceable collection which is consulted daily by those seeking information regarding aeronautics. Many requests for information have been received by mail. This service will expand next year to proportions which will render highly valuable assistance to members. In each Journal members find a record of the many gifts to the library and the Institute and while it would be fitting to mention several names in particular, it is perhaps advisable, as there are so many whom we should thank, for your President just to express thanks to all who are assisting in making the Institute a great information center. From assurances we have received our Library will play a more active part in its service to members during the coming year than ever before.

Headquarters Activities. The ever-expanding activities of the Institute have made it again necessary to have larger offices. By a fortunate arrangement with the officials of Rockefeller Center the Institute will move to offices which will be adequate for its needs for several years. Members will recall that when Rockefeller Center was first opened, the Institute was among its first tenants. For two years it was almost a guest and for the past few years recognition has been given to the special character of the Institute's work so that it has been able to stay in the most interesting group of buildings in New York. The Institute appreciates the courtesies it has received and looks forward to its new facilities with the hope that it will be able to render greater service, not only to members, but to all who request assistance on any matter pertaining to aeronautics.

Members who have visited the offices in Rockefeller Center have been impressed, I am sure, with the particularly efficient and loyal staff conducting the ever-growing activities of the Institute, which require specialized and experienced attention. On your behalf I wish to compliment them on their devotion to their work, praise them for the capable way with which the various activities are conducted and thank them for their untiring zeal.

Last year the Council decided that Major Gardner should be relieved of the duties of Secretary so that he could have more time to assist and represent the President in the work of the Institute. He was therefore elected Executive Vice-President. He has been succeeded by Mr. C. E. Sinclair, formerly with the N.A.C.A., and who has been with the Institute since its early days. To them both I wish to express my personal thanks for the assistance they have given me during the past year.

GEORGE W. LEWIS

THE TREASURER'S ANNUAL REPORT

The financial statement of the Institute for the fiscal year, gives members, I hope, a detailed accounting of the work done during the year and the present status of our finances. As members will see we have not spent more than we have received and have closed the year with a slight favorable balance.

The assets of the Institute have increased from $35,776.91 to $46,149.64. If we used the market value of securities which we own it would add $2,482.50 to our assets.

Annual Balance Sheet as of September 30, 1939

ASSETS

General Fund Assets			
Cash on Hand and in Bank		$1,276.90	
Deposits and Advances		550.00	
Accounts Receivable		3,415.36	
The Benefactor Membership Fund:			
U.S. Treasury Bonds at Par Value (Market Value $10,118.75)	$10,000.00		
Unamortized Bond Premium	32.40	10,032.40	
Office Furniture and Equipment	7,791.91		
Less: Reserve for Depreciation	3,026.81	4,765.10	
Prepaid Expenses		824.76	
Library—Books		1.00	
Aeronautical Index		1.00	
Total General Fund Assets			$20,866.52
Restricted Fund Assets			
The S. A. Reed Fund:			
U.S. Treasury Bonds at Par Value (Market Value $10,118.75)	$10,000.00		
Accrued Interest Receivable on Bonds	11.98		
Cash on Deposit for Award	317.11		
Total S. A. Reed Fund		$10,329.09	
The Lawrence Sperry Fund:			
U.S. Treasury Bonds at Par Value (Market Value $4,047.50)	4,000.00		
Accrued Interest Receivable on Bonds	4.80		
Cash on Deposit for Award	314.34		
Total Lawrence Sperry Fund		4,319.14	
The Vernon Lynch Fund:			
Melville Shoe Corporation Stock (Market Value $6,843.75)	5,062.50		
Peoples Drug Stores, Inc., Stock (Market Value $5,688.75)	5,272.50		
Cash on Deposit for Award	299.89		
Total Vernon Lynch Fund		10,634.89	
Total Restricted Fund Assets			$25,283.12
Total Assets			$46,149.64

LIABILITIES, FUNDS AND UNEXPENDED INCOME

General Funds			
Accounts Payable		$ 429.92	
Deferred Credits to Income:			
1940 Students Dues Paid in Advance	$ 7.00		
1940 Member Dues Paid in Advance	5,150.50		
1940 Corporate Member Dues Paid in Advance	120.87		
Unearned Corporate Member Dues	5,779.00		
Unearned Subscriptions	1,789.17		
Total Deferred Credits to Income		12,846.54	
Unexpended Income			
Balance, October 1, 1938	5,584.62		
Prior Years Depreciation Adjustment	1,087.07		
Net Unexpended Income Year Ended September 30, 1939	918.37		
Balance September 30, 1939		7,590.06	
Total General Funds			$20,866.52
Restricted Funds			
The S. A. Reed Fund:			
Principal	$10,000.00		
Unexpended Income	329.09	$10,329.09	
The Lawrence Sperry Fund:			
Principal	4,000.00		
Unexpended Income	319.14	4,319.14	
The Vernon Lynch Fund:			
Principal	10,335.00		
Unexpended Income	299.89	10,634.89	
Total Restricted Funds			$25,283.12
Total Liabilities, Funds and Unexpended Income			$46,149.64

Statement of Income and Expenses for the Fiscal Year Ended September 30, 1939

INCOME

Member Dues (Net after applying $5.00 per member for Journal)	$ 3,711.87	
Entrance Fees	905.00	
Donations	200.00	
Emblems—Net	269.78	
Corporate Member Dues	12,194.98	
Miscellaneous	15.00	
Income	17,296.63	
Net Income from Journal Publication (see detail below)	200.73	
Total Income		$17,497.36

EXPENSES

Administration, Clerical and Accounting		$10,224.59	
Rent		957.34	
Electricity, Telephone and Telegraph		381.07	
Office Supplies, Stationery and Printing		511.70	
Postage		586.67	
Travel and Guest Reception		794.31	
Library and Index Project		476.77	
Meetings—Expense	$3,663.42		
Less—Income	3,117.87	545.55	
International Congress		935.74	
Miscellaneous		504.28	
Uncollectable Accounts		284.96	
Depreciation		376.01	
Total Expense			16,578.99
Net Unexpended Income for Year Ended September 30, 1939			$ 918.37

Detail of Journal Income and Expense—Journal Publication

INCOME

Corporate Member Dues	$ 9,194.98	
Subscriptions	14,908.64	
Reprint Sales—Net	21.18	
Total Income		$24,124.80

EXPENSES

Administration, Clerical and Accounting		$10,224.60	
Rent		957.34	
Engraving, Postage and Printing		10,623.13	
Electricity, Telephone and Telegraph		381.07	
Office Supplies, Stationery and Printing		511.72	
Travel, Guest Reception and Miscellaneous		850.19	
Depreciation		376.02	
Total Expense			23,924.07
Net Income from Journal Publication (to Institute Income)			$ 200.73

The valuable library and great Aeronautical Index, as you will see, are still valued on our statement at the nominal figures of $1.00 each. As the cost of these two assets of the Institute was many thousands of dollars they represent a value probably greater than the more liquid assets.

The liabilities of the Institute to others is negligible. It has been the policy of the Council to incur no obligations for which funds were not available or promised.

The surplus of the Institute without including the library and the Index after liberal allowances have been made for depreciation is now $7,590.06.

We credit one half the dues from Corporate Members to the Journal and one half to Institute income as has been previously done.

I give the progress of the Institute finances from its organization:

	Total Assets	Total Income	Total Expense
1933	$ 1,176.92	$ 3,572.00	$ 2,866.99
1934	7,717.18	19,223.04	15,757.41
1935	6,338.22	18,316.14	17,853.66
1936	20,906.90	23,546.78	23,285.35
1937	23,497.66	29,061.39	28,653.25
1938	35,776.91	36,147.73	35,865.80
1939	46,149.64	41,421.43	40,503.06

The income of the Institute has increased slightly over that of last year. Members will note that the cost of administration and other expenses have been kept to a minimum.

The books have been audited by public accountants and they have reported that the books were kept in accordance with good accounting practice and the financial statement submitted herewith reflected the present state of the Institutes finances.

CHARLES H. COLVIN

THE SECRETARY'S ANNUAL REPORT

Since the reports of the President and Treasurer have dealt very thoroughly with most of the important aspects of the Institute's activities, the chief duty of the Secretary at this time is to report on the membership for the calendar year just ended.

The following are the membership figures by grades and the summary of changes in membership:

	Jan. 1, 1939	Jan. 1, 1940
Honorary Fellows	15	17
Honorary Members	14	16
Fellows	151	167
Associate Fellows	504	513
MEMBERS	283	399
Technical Members	505	891
Student Members	957	828
Total	2,423	2,823

Total Membership on January 1, 1939	2,423
Members elected during 1939	457
Members deceased during 1939	8
Members resigned during 1939	8
Members dropped during 1939	41
TOTAL MEMBERSHIP ON JANUARY 1, 1940	2,823

The net increase in membership during the past year is substantial. A total of only 49 resigned and dropped from our total of 2823 members indicates the high esteem in which membership in the Institute is held. The decrease in Student Membership, which is on a year to year subscription basis is undoubtedly due to the increase in annual dues from one dollar to $2.50.

In regard to the admission of new members the Institute should be grateful to the Admissions Committee for the faithful service they have rendered the Institute in reviewing and grading the groups of applications for membership which have been put before them every four or five weeks during the past year. Their work in properly grading applicants contributes greatly to the value placed on membership in the Institute.

With the greatly expanded facilities which the Institute will have at its disposal next year, the new services to be rendered to members are expected to attract a larger number of new members than ever before.

C. E SINCLAIR

The reports were unanimously approved.

The Secretary then presented the list of honors conferred by the Institute and Fellows, Honorary Fellows, and Honorary Members who had been elected.

LIST OF HONORS CONFERRED BY THE INSTITUTE OF THE AERONAUTICAL SCIENCES DURING 1939

The *Sylvanus Albert Reed Award* for 1939 was awarded to George Jackson Mead *"for the design and development of high output aircraft engines for military and commercial services."*

The *Octave Chanute Award* for 1939 was awarded to Edmund T. Allen *"for his outstanding contributions to methods and procedure in flight research in connection with airplane design and operation."*

The *Lawrence Sperry Award* for 1939 was awarded to Charles M. Kearns, Jr., *"for the successful application of methods of measuring propeller vibration stresses in flight."*

The Wright Brothers Lecturer on December 16, 1939, was Dr. Clark B. Millikan of the California Institute of Technology.

HONORARY MEMBERS

Hon. Robert H. Hinckley, Chairman, Civil Aeronautics Authority.

Rear Admiral J. H. Towers, Chief, Bureau of Aeronautics, Navy Dept.

HONORARY FELLOWS

Geoffrey I. Taylor, Professor, Trinity College, Cambridge, England.

Dr. Hugh L. Dryden, Chief, Mechanics and Sound Div., National Bureau of Standards.

AMERICAN FELLOWS

John L. Atwood, Vice-President and Assistant General Manager, North American Aviation, Inc.

Don R. Berlin, Chief Engineer, Curtiss Aeroplane Div., Curtiss-Wright Corp.

Hall L. Hibbard, Vice-President and Chief Engineer, Lockheed Aircraft Corp.

Robert L. Insley, Assistant Chief Engineer, Pratt & Whitney Aircraft, United Aircraft Corp.

S. M. Kraus, Head of Materiel Div., Bureau of Aeronautics, Navy Dept.

William Littlewood, Vice-President in charge of Engineering, American Airlines, Inc.

Robert J. Minshall, Vice-President and Assistant General Manager, Boeing Aircraft Co.

Mac Short, President, Vega Airplane Co.

Donald H. Wood, Aero. Engineer, N.A.C.A.

FOREIGN FELLOWS

Robert A. Frazer, Aerodynamics Dept., National Physical Laboratory, England.

Arthur H. Hall, Chief Supt., Royal Aircraft Establishment, England.

W. Lockwood Marsh, Founder Editor, "Aircraft Engineering," England.

M. Panetti, Manager, Aero. Laboratory, R. Politecnico di Torino, Italy.

Sir Francis C. Shelmerdine, Director-General of Civil Aviation, Air Ministry, England.

Albert Toussaint, Professor, Institut Aeronautique, St. Cyr l'Ecole, France.

Sir Alliott Verdon-Roe, President and Director, Saunders-Roe Ltd.; Chairman, Aviation Developments Ltd., England.

Charles C. Walker, Chief Engineer and Director, De Havilland Aircraft Co. Ltd., England.

George S. Wilkinson, Director and Chief Engineer, D. Napier & Son Ltd., England.

Emile B. Wolff, Director, Nationaal Luchtvaartlaboratorium, Netherlands.

The President called upon Professor John D. Akerman to read the report of the Committee on Student Affairs.

Report of Committee on Student Affairs

In the year 1939 there were 27 Student Branches, with a total membership of 828 on December 31st. During the year the Institute supplied eight illustrated lectures for the Student Branches.

On December 15, 1939, I sent out a questionnaire containing eight questions. Following is a résumé of the answers received:

Twenty-two schools out of twenty-six replied to the questionnaire.

On the basis of the questionnaire it was estimated that a total of 164 lectures were delivered at Student Branch meetings. The total attendance was approximately 7,500 persons. Of the total number of meetings approximately 130 used the material supplied by the Institute and 34 used different material.

All branches, except one, wanted the Institute to continue sending out lecture material.

The student members now constitute 56 percent of the eligible students in the schools.

As suggestions for improving the activities of the Student Branches of the Institute, twelve did not have any suggestions and eleven made definite suggestions. Their suggestions were as follows: (1) They would like to have moving pictures with the lectures. (2) Some lectures should be on popular subjects and not too technical. (3) Most of the branches would like to have a lecturer available from the Institute.

In reply to the question "What new service would you like to have the I.Ae.S. render the Student Branches?" the majority expressed a desire to have: (1) Visiting speakers. (2) Aeronautical films. (3) Student prizes.

John D. Akerman

The report was approved as read.

Dr. Lewis expressed the appreciation of the Institute to Professor George B. Pegram and Columbia University for the use of the facilities of the Pupin Physics Laboratories and the Men's Faculty Club during the three-day technical sessions of the Annual Meeting.

The Secretary announced the officers of the Institute for 1940, elected by the Council at their last meeting on January 18, 1940.

President—J. H. Doolittle
Vice-Presidents—W. A. M. Burden
Sherman M. Fairchild
R. H. Fleet
H. J. E. Reid
Exec. Vice-President—Lester D. Gardner
Treasurer—Leroy R. Grumman
Secretary—C. E. Sinclair

Dr. Lewis introduced J. H. Doolittle, the new President, and invited him to take the chair.

Major Doolittle expressed his appreciation of the honor conferred upon him and stated that he would do his utmost to expand the activities of the Institute and maintain the high standards set by his predecessors.

There being no further business, the meeting adjourned.

Book Reviews

Aircraft Design, Vol. II, Aerostructures, by C. H. Latimer Needham; Chemical Publishing Co., New York, 1939; 308 pages, $6.50.

This is the second of two volumes dealing with aircraft design, the first of which was entitled "Aerodynamics." The present book concerns itself with the structural analysis and design of airplanes.

Similar to other books of this nature written expressly for those engaged in airplane design projects subject to the British Air Ministry regulations regarding design flight conditions and other requirements at variance with American practice, this work is not entirely suitable as a text or reference book in the United States. From the standpoint of the fundamental mechanics of aircraft structures, the book is satisfactory.

Chapters I to IV cover the subjects of general layout, load factors, and materials. Some excellent subject content is presented but differences in nomenclature, load factor requirements, and in methods of performance calculations with our usual practices are already apparent.

The chapter on strength of structures presents mainly the accepted analytical expressions for the calculation of stresses under various types of loads and load combinations for structures whose failure is determined by the yield point or ultimate strength of the material.

The following chapters are concerned with the design of the main airplane components, the wings, fuselage, landing gear, and tail surfaces. Methods of design procedure are presented with appropriate formulas for the usual type of structures. Similar subject matter is subsequently offered in chapters on power units, control systems, and seaplane hulls and floats.

Another chapter on metal construction concerns itself with simple illustrations of metal construction in a few airplane parts. There is decidedly a lack of sufficient information for structural analysis of the stressed-skin type of construction. The final chapter deals with experimental testing.

The appendices treat first the practical aspects of spinning and flutter of airplanes, then the calculation of the spanwise load distribution over tapered and twisted wings. Thirdly, the aero-

dynamic characteristics of several well known airfoil sections are presented, and are followed by curves of the strength of tubes and struts.

The book has a great many fine cuts showing photographs and diagrams illustrative of modern British airplane construction. An abundance of sketches and numerical examples enhance the value of the book.

According to the preface, this book is intended "to meet the need for an up-to-date work dealing with the general principles of aircraft design." This requirement is, in the main, fulfilled, if not entirely satisfactorily from the American point of view. It is doubtful, however, that the book could be used extensively as a guide or text by those engaged in airplane design beyond the fundamental stage.

R. P. HARRINGTON
Polytechnic Institute of Brooklyn

The Mechanical Inventions of Emanuel Swedenborg, translated and edited by ALFRED ACTON; Swedenborg Scientific Association, Philadelphia, 1939, 51 pages, $0.60.

This pamphlet describes all of the known inventions of Emanuel Swedenborg, the Swedish inventor. They are collected from various publications by Mr. Swedenborg and with few exceptions, the diagrams are those appearing in the original sources. The first account of the majority of them is contained in a letter to his brother dated 1714. Included in the inventions is a description of a flying machine with flapping wings, operated by a coil spring, and a sail. Stability was to be achieved by a long rod projecting vertically downward. Most of the material is quoted from original sources and makes interesting reading.

How to Be an Aviator, by DICK MERRILL and GEORGE DAWS; Robert M. McBride and Company, New York, 1939; 192 pages, $2.00.

With the extensive training program of the Civil Aeronautics Authority inspiring the widespread interest of young men and women in flying, it is natural that many who are not able to avail themselves of this training will want to know how they, too, can learn to fly.

In this book one of the best known pilots of the United States gives a well written and profusely illustrated account of the various ways to take flying instruction. The chapters explain how the civilian schools, the Air Corps, and the Navy train pilots. There is a note of caution sounded many times which warns over-ambitious students of the physical, educational, and financial difficulties to be overcome. Captain Rickenbacker sums it up in his introduction when he states that a pilot must have specified formal education, be in excellent physical and mental health, have a regard for clean living, and observe the inherent qualities of a gentleman.

The many illustrations are well chosen and add greatly to the interest of the text. It is a book which every boy who has ambitions to follow a career in aviation can read with great benefit.

Pressure and Temperature Variations in the Free Atmosphere over Boston (Harvard Meteorological Studies No. 3), by B. HAURWITZ and E. HAURWITZ; Harvard University Press, Cambridge, 1939; 74 pages, $0.90.

Data obtained by radio soundings made by the Blue Hill Meteorological Observatory of Harvard University, the Massachusetts Institute of Technology, and the U.S. Weather Bureau during February and March, 1937, and from October, 1937, to June, 1938, are analyzed with a view to finding the interdiurnal variations of pressure and temperature for every dyn. km. level. Mean values were computed and are grouped according to the variations of surface pressure and temperature and according to the variations of the tropopause. In the second section, standard deviations, correlation coefficients, etc., for a number of meteorological variables are given. The third section concerns the questions of the coincidence of temperature variations at the earth's surface and at heights. The amount of advection of air in different layers of the atmosphere from day to day is described in Section IV. An extensive bibliography is given.

Experimental Studies of Anemometers (Harvard Meteorological Studies No. 4), by STERLING PRICE FERGUSSON; Harvard University Press, Cambridge, 1939; 101 pages, $0.90.

The author has compiled all of the known experimental work on all types of anemometers regularly used for measuring atmospheric wind velocities. The more fragile types, *e.g.*, hot-wire anemometers, are not treated. The method of test, limitations, and methods of construction are treated in detail. A complete bibliography is included.

Sky Riders, Wm. Collins Sons and Company, Ltd., London, Glasgow, and New York, 1939; 238 pages, $2.00.

Passing in review in this book are almost all of the fliers who have won fame by flights that have established new records, explored new territory, or pioneered the air routes of the world.

The unnamed author gives brief pen pictures of the achievements of men whose names have become famous. The first chapter, which reviews the aeronautical events of 1939, brings the book up to the minute.

As might be expected, British aircraft and achievements are emphasized, but not in an objectionable sense. Pilots of other countries are given adequate consideration and their contributions fairly evaluated. Pictorially the book is excellent and, as the text avoids technicalities, the general reader will acquire a good idea of the epic flights of this century.

How Strong Is Britain?, by C. E. COUNT PÜCKLER; Veritas Press, New York, 1939; 239 pages, $2.50.

The title of this book is an oft-repeated question. While the general public thinks usually in terms of military, naval, and air strength, the better informed reader knows that the ability to create war strength is based on economic and political factors. This book, by a former German newspaper correspondent in London, was published in Germany in the spring of 1939 and is conceded by English reviewers to be accurate in its facts and sound in its opinions.

It surveys the status of Great Britain in industry, agriculture, shipping, and banking with a view to determining whether in each of these fields the English have gone forward or backward since the World War. It is a general conclusion that in most fields there has been an advance. The political situation, particularly as it concerns the dominions and possessions, is examined, and the informed comment shows great familiarity with recent developments.

Using these as a base, the strengths of the army, navy, and air force are studied to determine whether or not they can be relied upon to defend the new conditions which might be expected in case of war.

In conclusion it is interesting to hear from a German the following opinion:

"The British Empire is the greatest empire in the world. Great Britain has command of the seas and she is richer than any other nation. In modern history she has never been defeated by force of arms, and by 1941–42 she will stand before the world powerfully armed indeed. With all its riches and all its power the British Empire has determined on a great undertaking. It wishes to make itself the crystallization point of a new and bigger commonwealth of peoples, and one in which peace and justice will reign...."

Institute Notes

Technical Sessions of the Eighth Annual Meeting

The following papers were presented at the technical sessions of the Eighth Annual Meeting of the Institute, held on January 24, 25, and 26, 1940, at the Pupin Physics Laboratories at Columbia University. Over five hundred members and guests attended.

While some preprints of the papers were available at the time of the meeting the supply has been exhausted. As space in the Journal is available those papers selected for publication by the Editorial Board will be printed.

WEDNESDAY, JANUARY 24, 1940

9:15 A.M. to 12:30 P.M.—Simultaneous Technical Sessions

POWER PLANTS

L. S. HOBBS, Chairman

KENNETH CAMPBELL, Wright Aeronautical Corporation, **Predetermination of Aircraft Engine Cooling Requirements for Specific Flight Conditions.**

FRANK W. CALDWELL, Hamilton Standard Propeller Division, United Aircraft Corporation, **Effect of Variable Gear Reduction on Propeller Performance in Modern Airplanes.**

C. W. CHILLSON, Curtiss Propeller Division, Curtiss-Wright Corporation, **Reversible Pitch Propellers as Applied to Water Handling of Multi-Engine Flying Boats.**

R. S. BUCK, Pratt & Whitney Aircraft Division, United Aircraft Corporation, **Mechanically Driven Supercharging.**

METEOROLOGY

F. W. REICHELDERFER, Chairman

P. G. CLARK, Pan American Airways, and H. R. McQUEEN, U.S. Weather Bureau, **Meteorological Service in Relation to Scheduled Transatlantic Flying in the Light of Operations during 1938.**

H. C. WILLETT, Massachusetts Institute of Technology, **Problems in Weather Analysis and Forecasting in Connection with Transatlantic Flying.**

D. M. LITTLE, U.S. Weather Bureau, **The Weather Bureau's Program for Transoceanic Flying.**

Simultaneous Technical Sessions

2:00 P.M. to 5:00 P.M.—AVIATION MEDICINE

L. H. BAUER, Chairman

A. D. TUTTLE, United Air Lines Transport Corporation, **The Organization of a Flight Surgeon's Office in an Operating Company.**

ROSS A. McFARLAND, Harvard University, **The Maintenance of Fitness in the Flight Personnel.**

HAROLD R. BOHLMAN, Baltimore, Maryland, **Problems Relating to Industrial Hygiene in the Ground Personnel.**

1:30 P.M. to 5:00 P.M.—METEOROLOGY

C. F. BROOKS, Chairman

G. EMMONS, New York University, **Analysis of Weather Map with Suggestions for Improved Presentation of Weather Information to the Public.**

C. S. DRAPER, Chairman

F. W. DUNMORE, National Bureau of Standards, **An Improved Electrical Hygrometer and its Applications.**

A. W. FRIEND, Harvard University, **Developments in Meterological Soundings by Radio Waves.**

R. CHAPPELL and K. WHITNEY, Julien P. Friez and Sons, **Comparison of the Olland and the Diamond-Hinman Types of Radiosonde as Regards Quantity Production and Service Performance.**

K. O. LANGE, Blue Hill Observatory, **Recent Developments in Olland Type Radiosonde.**

THURSDAY, JANUARY 25, 1940

9:15 A.M. to 12:30 P.M.—Simultaneous Technical Sessions

STRUCTURES

JOHN E. YOUNGER, Chairman

A. V. deFOREST and GREER ELLIS, Massachusetts Institute of Technology, **Brittle Lacquers as an Aid to Stress Analysis.**

R. L. TEMPLIN and R. G. STURM, Aluminum Company of America, **Some Stress-Strain Studies of Metals.**

TH. von KARMAN, H. S. TSIEN, and L. G. DUNN, California Institute of Technology, **The Effect of Curvature on the Buckling of Structures.**

HOWARD W. BARLOW, HENRY S. STILLWELL, and HO-SHEN LU, University of Minnesota, **Strength Investigations of Thin Stainless Steel Sections.**

E. W. CONLON, University of Michigan, **Magnesium for Aircraft Construction.**

RADIO AND INSTRUMENTS

W. G. BROMBACHER, Chairman

I. E. HOBBS, Naval Aircraft Factory, **Drift Determination in Aerial Navigation.**

HENRY I. METZ, Civil Aeronautics Authority, **The Civil Aeronautics Authority's Instrument Landing System Installed at Indianapolis.**

C. S. DRAPER and WALTER WRIGLEY, Massachusetts Institute of Technology, **Instruments for Measuring Low Frequency Accelerations in Flight.**

D. P. JOHNSON and W. G. BROMBACHER, National Bureau of Standards, **The Performance of Mercurial Barometers Used in Testing Altimeters.**

PRESTON R. BASSETT and JOSEPH LYMAN, Sperry Gyroscope Company, **Flightray, a Multiple Instrument Indicator.**

2:00 to 4:45 P.M.—Simultaneous Technical Sessions

AERODYNAMICS I

HUGH L. DRYDEN, Chairman

ABE SILVERSTEIN and S. KATZOFF, National Advisory Committee for Aeronautics, **A Simplified Method for Determining Wing Profile Drag in Flight.**

TH. von KARMAN, California Institute of Technology, **Some Paradoxical Velocity Distributions.**

R. von MISES, Harvard University, **New Developments in the Theory of Airplane Wings of Infinite Span.**

ALEX CHARTERS, California Institute of Technology, **Transition by Transverse Contamination.**

AIR TRANSPORT

J. A. HERLIHY, Chairman

S. B. KAUFFMAN, Pan American Airways, **The Development of Scheduled Transatlantic Service.**

ALBERT COTSWORTH, Chicago, Burlington and Quincy Railroad, **Passenger Comfort from the Railroad's Viewpoint.**

WILLIAM H. HUBNER, Ethyl Gasoline Corporation, **Prospects of Fuels of Higher Octane Number in the Transport Field.**

SYMPOSIUM, **Prospects of Fuels of Higher Octane Number in the Transport Field,** led by William H. Hubner; participants: R. C. Alden, D. P. Barnard, J. H. Doolittle, Gustav Egloff, R. E. Ellis, Raymond Haskell, W. M. Holaday, and J. R. MacGregor.

EDWARD P. WARNER, Civil Aeronautics Authority, **Looking into the Future with Respect to Air Transport Design.**

FRIDAY, JANUARY 26, 1940

9:15 A.M. to 12:30 P.M.—AERODYNAMICS II

EASTMAN N. JACOBS, Chairman

FREDERIC FLADER and E. RUSHMORE CHILD, Curtiss Aeroplane Division, Curtiss-Wright Corporation, **Studies of High Speed Airplanes.**

H. M. McCOY, U.S. Army Air Corps, Wright Field, **Counter-Rotating Propellers.**

ALEXANDER KLEMIN and T .C. WAKEFIELD, New York University, **Notes on Wing Slots in Relation to Airplane Design.**

FRANCIS M. ROGALLO, National Advisory Committee for Aeronautics, **Application of High Lift Devices to Airplanes Designed Primarily for High Cruising Speeds.**

E. A. STALKER, University of Michigan, **Probable Trends of Boundary Layer Control Applications.**

T. M. HEMPHILL, Consolidated Aircraft Corporation, **Control Surface Hinge Moments and Their Relation to Stability.**

1:30 P.M.

A motion picture on **Streamline Visualization,** prepared by C. WITOSZYNSKI of the Warsaw Polytechnic Institute, Poland, for the International Congress of the Aeronautical Sciences (see Supplementary Program below), was shown. These pictures, showing the streamlines about various types of bodies at fairly low speeds, were made by a modification of the schlieren method.

2:00 to 5:00 P.M.—AIRPLANE DESIGN

C. H. CHATFIELD, Chairman

OTTO C. KOPPEN, Massachusetts Institute of Technology, **Airplane Stability and Control from the Designer's Point of View.**

W. C. MENTZER and H. E. NOURSE, United Air Lines Transport Corporation, **Some Economic Aspects of Transport Airplane Performance.**

SUPPLEMENTARY PROGRAM

The following papers were prepared for presentation at the International Congress of the Aeronautical Sciences, scheduled for September 11 to 16, 1939. The Congress was postponed until 1941. These papers were presented in full or in summary form during the sessions designated.

AERODYNAMICS I

A. FAGE, National Physical Laboratory, England, **Experiments on the Breakdown of Laminar Flow.**

J. KAMPE de FERIET, Universite de Lille, France, **Spectrum of Turbulence.**

METEOROLOGY

J. PATTERSON and W. E. KNOWLES MIDDLETON, Meteorological Division, Department of Transport, Canada, **A New Electrical Weight Barograph.**

AVIATION MEDICINE

GUSTAV SCHUBERT, Physiologisches Institut der Deutschen Universitat, Czechoslovakia, **Stratosphere Flying and Caisson Disease.**

J. JONGBLOED, Physiologie-Laboratorium, Netherlands, **Tobacco Smoking, A Minor Problem in High Altitude Flight.**

POWER PLANTS

L. MASSUGER, Societe d'Exploitation des Materials Hispano-Suiza, France, **Testing Aircraft Engines in the Laboratory under Flight Conditions.**

D. R. POBJOY, D. R. P. Engines, England, **Light Aero Engines of Europe —Present and Future.**

LETTERS TO THE EDITOR

The Journal invites critical comments on the papers it publishes. Such comments should give new information on the subject or new interpretations of conclusions or data contained in the original articles. They will be published in the Journal under the heading "Letters to the Editor" as soon as possible after receipt.

This applies particularly to comments on papers delivered at the Annual Meeting. While the discussions of the papers presented will not be published as such, discussors are invited to submit brief pertinent remarks as Letters to the Editor.

It is suggested, however, that discussors withhold their comments until the articles in question appear in the Journal, since, in many cases, the published article differs materially from the first draft.

Brief announcements of new discoveries should also be made as Letters to the Editor.

GIFTS TO THE INSTITUTE

The Institute is greatly indebted to the donors of books, clippings, and other material of historical and technical interest. The following gifts have been received within the last month.

The Royal Aeronautical Society gave the following books: *6th Annual Report, R.Ae.S.* (1871); *23rdAnnual Report, R.Ae.S.* (1891–93); *Aerial Navigation*, by Sir George Cayley (1809); and the Aeronautical Classics: *Aerial Locomotion*, by F. H. Wenham (1866); *The Art of Flying*, by Thomas Walker (1810); *The Aerial Ship*, by Francesco Lana (1670); *Gliding*, by Percy S. Pilcher (1897); *The Flight of Birds*, by G. A. Borelli (1680).

The Simmons-Boardman Publishing Company gave copies of the following books: *Electrical Trouble Shooting on the Motor Car and Airplane*, by A. H. Packer (1929); *The World's Wings*, by W. Jefferson Davis (1927); *Aeroplanes, Seaplanes, and Aero Engines*, by P. H. Sumner (1930); *Civil Airports and Airways*, by Archibald Black (1929); *Pilot's Handbook* (1931); *Engine Dynamics and Crankshaft Design*, by Glenn D. Angle (1925).

William B. Stout gave a copy of the *English Airplane Catalogue.*

Howard J. Tierney, Jr., and W. DeWint Eckerson gave the Thomas Jefferson letter reproduced elsewhere in this issue of the Journal.

Dr. J. C. Hunsaker gave copies of the books, *My Airships*, by A. Santos Dumont (1904), and *Adventures in the Air*, by W. de-Fouvielle and J. S. Keltie (1877).

Mrs. James Howard Means gave an engraving of Dr. John Jeffries.

Dr. James Howard Means gave Volumes 1, 2, and 3 of the *Aeronautical Annual* (1895, '96, '97) and the following pamphlets by James Means: *Five Patents Relating to Aviation* (1909); *Signalling Apparatus for Aerial Machines* (1909), *Man Flight* (1891), and *The Problem of Man Flight* (1894).

J. A. Herlihy gave a United Air Lines Flight Calculator.

Arthur M. Sherwood gave many valuable clippings covering the years 1903–10.

C. R. Fairey gave a copy of *A Narrative of the Two Aerial Voyages by Doctor Jeffries and Mons. Blanchard*, by Dr. John Jeffries (1786).

Howard Scholle gave the book, *A System of Aeronautics*, by John Wise (1850).

Cox and Stevens Aircraft Corporation gave a Flight Coordinator for DC-3, a Load Adjustor for DC-3, and a Navigational Calculator.

The Ronald Press gave copies of the following books: *Aerostatics*, by E. P. Warner (1926); *Balloon and Airship Gases*, by C. deF. Chandler and Walter S. Diehl (1926); *Airplane Mechanics Rigging Handbook*, by R. S. Hartz and E. E. Hall (1930); *Pressure Airships*, by Thomas L. Blakemore and W. Watters Pagon (1927).

Dr. Michael Watter gave three reports by Prof. N. E. Joukovsky.

Mrs. Frank Hawks gave the valuable and extensive collection of clippings and papers of Frank Hawks.

The Lockheed Aircraft Corporation gave one copy of the film showing the measurement of the stall characteristics of the original Lockheed Model 14, which was not equipped with wing slots.

PERSONNEL OPPORTUNITIES

The Personnel Bureau serves individual members, as well as organizations seeking to employ aeronautical specialists. Any member or organization may have requirements listed without charge.

Wanted

A large midwestern university is considering the addition to its present staff of the following personnel: one Assistant Professor, two Instructors, and two Research Fellows. The Instructors and Research Fellows in addition to their salaries would be given the opportunity to do work in the Graduate School with free tuition, and should be interested in working either for their Master's or Ph.D. degree. The applicants for the Instructors' positions should have a Master's Degree; the Research Fellow applicants should have either a Bachelor's or Master's degree before applying. Address reply to Box 97, Institute of the Aeronautical Sciences.

Branches

Los Angeles. At a meeting of the Branch on January 31st, H. B. Dickinson of Lockheed Aircraft Corporation presented a paper on "Maneuverability and Maneuvering Load Criteria for Large Airplanes," representing a new and rational approach to the problem. Prepared discussions by W. W. Beman, L. E. Root, F. R. Shanley, and H. J. Stewart were given. The second part of the program was a motion picture prepared by the N.A.C.A. on "The Fundamental Nature of Air Flow and Air-Flow Separation." Following the technical session the following officers for the current year were elected: Richard W. Palmer, Chairman; Major E. A. Peterman, Vice-Chairman; J. Richard Goldstein, Secretary and Program Director; E. J. Horkney, Treasurer.

Seattle. At a meeting of the Branch on December 29th Mr. George Haldeman, C.A.A. Senior Engineering Inspector, spoke on "Early Transatlantic Flight Problems." An early transatlantic flyer, Mr. Haldeman spoke on many problems from first-hand experience. An interesting discussion followed the presentation. About 90 members and guests attended the meeting.

Student Branches

Aeronautical University. At the first meeting of the Student Branch Charles Laher gave the branch lecture on "Safety from the Ground Up" by Jerome Lederer. The next lecture on "Aviation Fuels" by Dr. Graham Edgar was presented by Alfred Scott on November 30th. About 40 members and guests attended each meeting.

Polytechnic Institute of Brooklyn. At a meeting on January 11th, Sebastian V. Nardo gave the branch lecture on "Safety from the Ground Up" by Jerome Lederer. About twenty members and guests attended the meeting.

University of Minnesota. The branch lecture on "Aviation Fuels" by Dr. Graham Edgar was presented by Prof. B. J. Robertson at a meeting of the Student Branch on November 27th. Prof. Robertson presented in addition some original material demonstrating the need for proper vaporization of fuel. Sixty members attended the meeting.

Stanford University. At a meeting of the Student Branch on November 6th Charles W. Frick presented the branch lecture "Aviation Fuels" by Dr. Graham Edgar.

New Address of the Institute

The Institute is moving shortly from its offices at 5111 RCA Building to larger quarters at 1505 RCA Building West, 30 Rockefeller Plaza, New York City. The latter address will go into effect on February 20th, 1940. To reach the new offices the bank of elevators near the 6th Avenue entrance to the building must be used.

Changes in Membership

The following changes in the membership of the Institute have occurred since the publication of the previous issue of the Journal:

Elected to Member Grade

Lunde, Otto Helmer, Ae.E.; M.I.Ae.S.; Prof. and Head of Dept., Aero Engineering, Univ. Alabama. (See B.B. of A.; W.W. in A.A.)

Elected to Technical Member Grade

Horkey, Edward James, M.S. in M.E.; Aerodynamicist, North American Aviation, Inc.

Longden, John Leslie, B.A.; Pilot Officer, R.A.F.V.R., England.

Parsons, John Whiteside, Research Assistant, Jet Propulsion Research, Calif. Inst. Technology.

Schmidt, Carl Frederick, M.Ae.E.; Aero. Engineer, American Export Airlines, Inc.

Webb, Henry Gorham, B.S.; Aviation Cadet, U. S. Marine Corps Reserve.

Zemansky, Stanley Donald, S.B. in Ae.E.; Asst. Research Engineer, North American Aviation, Inc.

Transferred from Technical Member to Member Grade

John M. Luther, Power Plant Layout, Curtiss Aeroplane Div., Curtiss-Wright Corp.; Lt. H. M. McCoy, Director, Propeller Projects, Propeller Lab., Material Div., U.S. Army Air Corps.

Transferred from Student Member to Technical Member Grade

E. Amanuel; J. E. Bartfield, Stress Analyst, Bell Aircraft Corp.; E. Barron Batchelder, Assistant to Patent Attorney; Sidney Batterson, Jr. Engineer, N.A.C.A.; Hans Bebie, Draftsman, Glenn L. Martin Co.; Lt. Richard Berne, U.S. Army; Willard B. Boothby, Jr. Aero. Engineer, N.A.C.A.; R. E. S. Boss, Jr., Engineer, Brewster Aero. Corp.; John D. Bowen, Jr. Aero Engineer, N.A.C.A.; J. Arthur Boykin, Jr.; C. Stewart Brandt, Aero. Engineer, Ryan Aeronautical Corp.; C. G. Bull; Robert A. Burbick, Taylorcraft Airplane Co.; Charles J. Buzzetti, Engineer, Lockhead Aircraft Corp.; M. E. Cushman, Stress Analyst, Curtiss Propeller Div., Curtiss-Wright Corp.; Will S. Davies, Draftsman, Vought-Sikorsky Div., United Aircraft Corp.

Necrology

Donald Lamont Brown

Donald Lamont Brown, a Member of the Institute and President of the United Aircraft Corporation, died January 29, 1940, at the age of 49.

Mr. Brown had a remarkable career as an aviation executive. Born in Berlin, Wisconsin, on November 17, 1890, he attended high school in that city and the School of Commerce at Northwestern University. His aviation activities began in 1915 when he started work in the production department of the Simplex Automobile Company in New Brunswick, New Jersey. The company was producing Hispano-Suiza engines for the French government. In 1917 when the company reorganized and became the Wright-Martin Aircraft Corporation, he was placed in charge of its assembly department in Long Island City, New York. He was made assistant factory manager of the Wright Aeronautical Corporation in Paterson, New Jersey, in 1921. In 1925 when the Pratt and Whitney Aircraft Company was organized in Hartford, Mr. Brown was made factory manager of the new plant. In the same year he was made a Director and Vice-President in charge of engineering of the company. In 1929 he was president of the company when it became a subsidiary of the United Aircraft and Transport Corporation. He was made Vice-President and Director of the new corporation. In 1934 he became President of the United Aircraft Corporation.

George Mallory Pynchon, Jr.

George Mallory Pynchon, Jr., a Member of the Institute, died in Jericho, Long Island, on January 15, 1940, at the age of 36.

Born in Greenwich, Connecticut, on June 3, 1903, Mr. Pynchon was educated at Groton School and at Yale University where he received a B.A. degree in 1925.

At the time of his death he was a Director of the Consolidated Aircraft Corporation and Vice-President of Hammons and Company. He was a Lieutenant in the U.S. Army Reserve Corps and held commercial and transport pilot licenses.

Aeronautical Reviews

These brief reviews of recent articles on aviation subjects are published by the Army Air Corps for the information of its officers, and are printed here each month by permission of the Chief of the Air Corps

Aerodynamics

Closed-Return Type 42-Inch Wind Tunnel. R. P. Harrington. Wind tunnel used at the Polytechnic Institute of Brooklyn in connection with its aeronautical engineering courses is a single closed-return type with an open throat 42 in. square and 48 in. long which may be reduced to 30 × 42 in. Satisfactory flow conditions obtained, propeller installation, tunnel energy ratio, the features from two tunnel designs (California Institute of Technology and Aerodynamic Institute of Aachen) which were adopted in the final design of the tunnel, and the balances are described in detail. *Aero Digest*, December, 1939, pages 46–48, 68, 10 illus.

Aircraft Design

The Argument for a Lighter Fighter. Instead of concentration on one type of fighter, three types are suggested, the light cheap fighters built in large quantities for constant patrolling of vital areas, the high-speed single-seaters of the Hurricane-Spitfire type for intercepting enemy raids "from the ground up," and the larger heavily-armed long-range fighters for escorting big bombers.

The hypothetical mass-produced light fighter described would be easy to fly and have tricycle landing gear, ply-covered monocoque fuselage, and be powered with a 445-hp. engine. It would have a wing loading of 35 lb./sq.ft., top speed of 318 m.p.h., rate of climb of 2000 ft./min., and service ceiling of 21,500 ft., would be armed with four machine guns, and would cost £3000. Table compares dimensions and performances of four successively heavier types, the Percival Mew Gull (as a military airplane), the hypothetical airplane described, the Caudron Cyclone (450-hp. engine, top speed 302 m.p.h., service ceiling 29,800 ft., 4 machine guns, duration 2.75 hours), and the eight-gun Hurricane fighter.

Editorial states that argument is not convincing. Speed is the predominating factor and that of 318 m.p.h. is not fast enough. *Aeroplane*, November 23, 1939, pages 640–641, 2 illus., 1 table.

An Ex-Transport Pilot Writes of Transports and Engines. D. C. Smith. Features of the new 36-passenger twin-engine Curtiss-Wright Substratosphere Transport emphasizing safety are referred to. Errors in the proposals to limit the number of passengers per engine that one airplane could carry, or to require airplanes above a certain weight class to have four engines are pointed out. *U.S. Air Services*, December, 1939, pages 15–16, 2 illus.

Comfort in Aerial Transport. E. D. Weiss. Means for making air-transport passengers comfortable during flight are discussed with illustrations of the interior of the Junkers Ju.160, fuselage of the Junkers Ju.85 during construction, and interior and layout of the Ju.90. *L'Aéronautique*, September, 1939, pages 346–348, 6 illus.

The Future of Flying. H. E. Wimperis. Possible speed, size, and range of aircraft of the future. Limitations imposed by engine power on size and by wing loading on speeds are considered. The author points out that in the case of military types having top speeds of 550 m.p.h. or thereabouts, landing speed could hardly be less than 150, giving a wing loading of 100 lb./sq.ft. It looks as though wing loadings for civil types will go little beyond what is now planned, but in the case of military types, present-day figures may certainly be doubled unless some new wing arrangement can be discovered that will greatly reduce the loading figure when a landing is about to take place. While speeds of military aircraft are now in excess of 400 m.p.h. and will rise still higher, civil aircraft rarely go faster than 250 m.p.h. and there is doubt whether even so high a speed as that is economically advantageous.

Some new developments in flying boats of today (which represent a great technical advance in quality, but not any marked advance in size), some important problems in aeronautics which are being investigated, and other problems arising with their solution are discussed. British Association paper. *Jour. Royal Aeronautical Soc.*, November, 1939, pages 875–883.

Transatlantic Airplane Design. R. J. Nebesar. Trend of development in size of seaplane and landplane designs is established from current modern American designs. The tell-tale charts of their characteristics, and mainly of useful load-range gross-load relations, are presented. It is assumed that a cruising speed above 200 m.p.h. for transatlantic travel is a necessity and it is deduced that, although seaplane design would have to go as far as a 100-passenger 100-ton size in order to fulfill the requirements, the landplane of about half this size would do.

Characteristics, weight, performance estimates, and the general outline with operation-cost figures are presented for a transatlantic landplane project for nonstop New York–Paris flight. Bright prospects of this solution are believed to be possible by systematic weight and drag savings. These savings would be facilitated by elimination of the otherwise necessarily big and heavy fuselage and by the advantageous wing arrangement, where comfortable accommodations for 48 passengers are provided and where the great gasoline load is distributed along the span. Project TA-2 is supplemented for comparative purposes with the project TA-1, differing only in fuel capacity. *S.A.E. Jour.* (*Trans.*), November, 1939, pages 478–484, 5 illus., 1 table.

Stress Analysis and Structures

Aircraft Engineering Data Sheets. First of a series of data sheets, designed to be of use to aeronautical engineers. Dimensions of standard bolts, nuts, washers, and split pins for the more usual B.S.F. and B.A. sizes (6 B.A. to $\frac{1}{2}$ in. B.S.F.), drawn to full scale with their A.G.S. numbers, are presented. *Aircraft Engineering*, November, 1939, page 416, many illus. on suppl. sheet.

The Design of Welded Components. W. Rethel. Recommendations to designers on planning for production. Four chief advantages and three disadvantages of welded components are pointed out. Edges on both sides of the joint to be welded should be such that they will assume the same temperature at the same time under the welding torch. Part having the thick wall should form an edge or tongue penetrating the thinner wall. Flanging is suggested where it is not possible to let the thin wall go through. All concave corners should be avoided, and double-sided corner welds are even worse. The more accessible a joint is, the quicker and safer will be the welding operation, and only butt joints, lap joints, and flanged seams should be used as far as possible. Precautions to be observed to safeguard against distortion and cracking are described.

Drawings include: common types of welded joint; welding of different thicknesses (strut ends, inset fittings, inset bushes); melting zones on a double-angle joint; angle joint showing swelling section of steel structure; a hollow stiffening webb; limits of buckling width for various types of sheet joints; and a chart for welding times for various common joints. Small welded structural components are shown in photographs. From Jahrbuch 1938, Deutschen Luftfahrtforschung. *Aircraft Engineering*, November, 1939, pages 425–427, 11 illus.

Gun Recoil. G. F. Wallace. Effect of gun recoil on aircraft stressing. When projectile weight, gun weight, muzzle velocity, and load extension curve for the buffer spring are known, the loads are easily calculated and they should be sufficient for purposes of preliminary design. When stressing the structure for this load it must be remembered that there is only a limited amount of energy available and that the maximum load cannot be chased right through the structure, but will decrease progressively as the energy is adsorbed in the deflecting structure. For any given gun and mounting structure, loads will be constant within fairly close limits, and a factor of safety of 2 only is required. An increase in gun weight means a decrease in recoil energy. The argument that any decrease in gun weight is more than offset by increase in recoil energy and consequent increase in structure weight, is shown not to be true because, whereas recoil load has a factor of 2, weight may have a factor of anything up to 10.

Loads likely to be imposed on the points of attachment of gun to mounting, two extreme relations of gun to mounting (gun rigidly attached to mounting, and gun recoiling freely a sufficient distance to attain its maximum recoil velocity), and the effect of flexibility are calculated. Method of obtaining loads imposed on the mounting structure and order of these loads are illustrated by an example worked out for a typical 20-mm. automatic gun. *Flight, Aircraft Engr. Sup.*, November 23, 1939, pages 47–49, 3 illus., 14 equations.

Shear Stress in Thin-Walled Tubes. C. K. Ovenston Problem of exact determination of shear stress in thin-walled tubes has been investigated by D. Williams. Principle is elaborated and extended to form a practical and very general method which enables many types of structure to be dealt with, such as slats, ailerons, monocoque and semi-monocoque wings, fuselages, and tail units.

The following diversities are encompassed: with or without stringers or longerons; skin covering or walls may be thick enough to support bending stress without stringers, or so thin that it can only support shear, the bending in such cases being supported by longitudinal stringers alone or perhaps with a small portion of stabilized skin; material may be homogeneous or mixed; gage thickness is not restricted to uniformity; section shape or contour is unrestricted so that any odd shape such as an airfoil section can be investigated; section may be closed or open; and position or localization of the total applied load is quite general (except for open sections), the difficulty in defining a flexural axis being overcome, and moments being considered about centroidal axis.

Academic theory is proved and some examples are worked out for simple shapes. A practical works routine which was developed for less amenable sections is described in some detail. *Aircraft Engineering*, November, 1939, pages 417–420, 6 illus., 2 tables, 12 equations.

A Treatise on Aluminium Handling. Aluminium Union's new cone-head rivet, developed for aluminum alloys, has the advantage of being cold driven with about half the pressure required for snap heads. This type of head, in addition to requiring less pressure to close it, gives a rivet strength equal to that of the usual types, requires a shorter length of shank for forming the head, and involves less danger of the heads breaking off. One size of rivet set suffices for closing several rivets of several different diameters. Drawing, and a few details are given in a review of a handbook on welding and riveting aluminum, issued by Aluminium Union, Ltd. *Aeroplane*, November 16, 1939, page 619, 1 illus.

Secondary Stresses of Bending and Shear Which Are Generated in the Torsion of the Prism with a Thin Wall. G. Maraschini. Approximate method of calculation is explained for the determination of the stresses of bending and shear which are generated in the torsion of a prism having a thin wall with a fixed end. Method is applied to the prism with opened section of a more common type or a closed rectangular prism, with load either concentrated at the free end or uniformly distributed. Possible extension of the method to the box wing structure of the shell type is considered. *L'Aerotecnica*, August-September, 1939, pages 853–873, 12 illus., 19 equations.

The Strength of Aeronautical Materials and Improved Wood. G. C. Cao. Characteristics of natural wood for aircraft structures; procedure for improving wood for aircraft structures and results obtained; improved wood joined by nails and glue; and advantages brought about by use of improved wood. Tables show characteristics of birch improved by the process of impregnation, and of beech improved by the gluing process, and a comparison between the resistance of glue with hot synthetic resin and that of other gluing substances. *L'Aerotecnica*, August-September, 1939, pages 843–852, 15 illus., 3 tables.

Structural and Other Uses of Stainless Steel in Airplanes. American Iron and Steel Institute standard type numbers and corresponding composition ranges of austenitic chromium-nickel stainless steels, and of ferritic and martensitic chromium steels, as well as the physical properties that recently published data show can be obtained in 18-8 chromium-nickel stainless steel are discussed and presented in tables. Advantages and applications of stainless steel in aircraft parts are considered, with recommendations for spot welding. Engine applications are also taken up. *Aero Digest*, December, 1939, pages 50–52, 54, 7 illus., 4 tables.

Structures in Light Materials. N. A. de Bruyne. "How closely stress is related to material density is explained. . . the argument of which leads to the somewhat startling suggestion that in certain cases it would be more profitable structurally to 'blow out' wood for particular purposes rather than to compress it."

Structure loading coefficient of a compression member for analysis of experimental results is described, and is plotted against failing stress for three types of profile. A hollow cylindrical section is considered so that moment of inertia is increased without enlarging the area of the section and, by so doing, the material is made to fail at approximately the original stress, despite the lower structure loading. There is a limit to which this process of "blowing out" can be carried and a different kind of instability occurs known

as "wrinkling" which is distinct from buckling in that it is a local condition unaffected by length. Optimum condition is to make the strut of equal strength in wrinkling and buckling.

Interpretation of experimental results and design of compression members are discussed. Comparative merits of materials in compression are given for very high structure loading, geometrically similar profiles, buckling and wrinkling of curved profiles and of flat sections, and for sheet material stiffened against shear and compression by stiffeners at a given separation. Figures of merit of materials under compression (steel, duralumin, electron, Aerolite, laminated beech, spruce, and balsa) are given for direct compression, Euler failure, buckling and wrinkling of curved profiles and flat sections, and buckling of sheet. Translation of and comments on article by H. Wagner from Z.f.M. 1928 and 1929. *Aeroplane*, November 30, 1939, pages 669–671, 2 illus., 2 tables.

Aircraft Alighting Gear

The Automobile Research Committee. Experimental equipment used in an investigation undertaken by the Institution of Automobile Engineers on the phenomena associated with overheating of tires and brakes on motor buses is described in detail, particularly the slip rings for selecting temperatures of rotating thermocouples and back axle and wheel test assembly. Results obtained are discussed. (Possibly of interest.) *Automobile Engineer*, October, 1939, pages 355–357, 7 illus.

Aircraft Manufacture

New Equipment. Jacoel cable splicer for thimble and bushings. Empire portable air compressor. Speedway Model 119 portable bench grinder. Taylor and Hobson jig aligning telescope. Wesson universal vise for use in connection with angular milling, grinding, and drilling operations. Grob combination band-sawing and chain-filing machine. Paramount "Minute Man" and Bruning blueprinting machines. Brief descriptions. *Aero Digest*, December, 1939, pages 113–114, 3 illus.

The Welding of Stainless Steel and its Alloys. G. H. Tweney. Recommendations are given for the gas welding of stainless steels, filler rod to be used, electric arc welding, and spot welding. References are made to the Fleetwings 5F amphibian "Sea Bird" and the "Pioneer," all-stainless-steel amphibian built by the Edward G. Budd Manufacturing Company. *Aero Digest*, December, 1939, pages 45, 54, 3 illus., 1 table.

S.A.E. Talks Production. C. F. McReynolds. Account of the 1939 S.A.E. National Aircraft Production Meeting. *Aviation*, November, 1939, pages 32–33, 84, 86, 108, 10 illus. *Western Flying*, November, 1939, pages 12–13, 17, 4 illus.

Magnesium Sheet for Aircraft. L. B. Grant. Abstract of paper entitled "Production of Magnesium Alloy Aircraft Parts," presented at the S.A.E. National Aircraft Production Meeting, and previously abstracted. *Aviation*, November, 1939, pages 36–37, 82, 3 tables.

Planning for Production. P. N. Jansen. Abstract of paper entitled "Accelerated Aircraft Production for National Defense," presented at the S.A.E. National Aircraft Production Meeting, and previously abstracted from preprint. *Aviation*, November, 1939, pages 34–35, 80, 5 illus.

Aircraft

With the R.A.F. in France. P. Masefield. Fighters in the field. Messerschmitt controversy is argued more hotly in France among French and British flyers even than in England. The anti-Messerschmitt school says that the Me.109 gets wing flutter, wings come off at more than 250 m.p.h., it is not very maneuverable, and it hasn't any cannon. Arguments on both sides are presented. Latest Me.109 with the 1150-hp. D.B.601 engine has a top speed of 354 m.p.h. at 12,300 ft. and a cannon through the propeller. With full load it lands at only 75 m.p.h. due to use of slots and slotted flaps. All Me.109s have night-flying equipment. There have been some spots of trouble with the adjustable tailplane.

Fight in which a Dornier Do.17 was downed, wreckage of the Do.17, and the escort problem are described. "The French pilots regard the Curtiss with admiration and affection and are loud in their praise of the Wasp motor. They fly the Curtiss magnificently." Reference is made to the Morane fighter and Potez 63 two-engine multi-seater fighter (two cannon and six machine guns, top speed 286 m.p.h. at 13,000 ft.). It is pointed out that armament may be sacrificed to speed, but never speed to armament, and that supremacy will only be maintained by getting new types in the field. *Aeroplane*, November 23, 1939, pages 634–636, 3 illus.

Germany

The Heinkel He.112 Fighter. Comments on weights and performance of the He.112 single-seater fighter, which was previously described, are given by the technical staff of Hawker Aircraft, Ltd., in the light of their design criteria. Claim that the fighter carries an armament of two 0.312-in. guns and two 20-mm. shell guns with ammunition, together with fuel for 715 miles at a normal loaded weight of 5740 lb. cannot be accepted. Either two types of gun are carried as alternative armament, or normal loaded weight is somewhat more than stated.

Heavy armament and long range of so small an aircraft are considered the most striking features of the He.112. Summary of the normal weights quoted are given and studied to see how weight of this formidable armament has been included. Item of "armament, oxygen, etc." is analyzed from experience with Hawker aircraft and approximate weights are tabulated, a discrepancy of 200 lb. being found. Weight empty, given as 4200 lb. is analyzed to ascertain whether it includes guns and mountings. In regard to performance, total skin area appears to be about 125 sq.ft. less than that of the Spitfire, and on this basis of comparison, maximum level speed of 358 m.p.h. at such a low altitude as 12,300 ft. seems a little high. Service ceiling is very high for a wing loading of 31.4 lb./sq.ft. in conjunction with an engine of low altitude rating. Five fuel tanks would be required to accommodate the 126 gal. which is not sufficient for a range of 1555 miles at 236 m.p.h.

Editorial note states that He.112 fighters with D.B.601 engine are flying with two cannon in the wings and two machine guns on the fuselage. There is evidence that He.112s are being kept in Germany for interception duties which would agree with the supposition of short duration. *Aeroplane*, November 30, 1939, page 672, 1 illus., 3 tables.

Henschel Hs. 126 Reconnaissance Monoplane. Hs.126 two-seater high-wing braced monoplane has a B.M.W. 132 Dc radial engine developing 870 hp. at 8200 ft., giving it a top speed of 221 m.p.h. at 9850 ft. and normal endurance of 3.75 hr. at 187 m.p.h. at 13,100 ft. Airplane is being used for short-range photographic work over the Maginot Line and at least three have been shot down in France during the past few weeks. Production has now stopped at the Henschel works which have been turned over to building Heinkel He.111K-V bombers. Flying characteristics, construction, engine mounting, crew accommodation, operation of controls, characteristics, loadings, and performance are described in detail. Cutaway drawing shows structure and location of equipment. *Aeroplane*, November 30, 1939, pages 666–668, 3 illus., 1 table.

Flight Identification Chart of German Aircraft. Five drawings showing various views are given for each of the following: Heinkel He.112U; Messerschmitt Me.109; Henschel Hs.123; Arado Ar.95; Henschel Hs.126; Junkers Ju.87; Messerschmitt Me.110; Dornier Do.17; Dornier Do.215; Junkers Ju.88; Heinkel He.111K; Junkers Ju.86K; Heinkel He.115; Dornier Do.-18K; Dornier Do.24; and Junkers Ju.89 (one view). Purpose, crew, armament, and other details are also given for each aircraft with the exception of the last. *Flight*, November 16, 1939, pages 396b–396c, 76 illus.

The Heinkel He. 112 Fighter. Performance of the standard He.112 fighter is not so startling as that of the record-breaking He.112U. Latest version has a 1150-hp. Daimler-Benz D.B.601A engine which gives a top speed of 358 m.p.h. at 12,300 ft. The He.112s of certain squadrons have been equipped with long-range tanks for bomber-escort duties and have a wing loading of 35.4 lb./sq.ft. and a maximum range of 1555 miles at 236 m.p.h. at 13,120 ft. Standard armament is two 0.785-in. shell guns in the wings and two 0.312-in. machine guns in troughs at the sides of the cowling around the engine. Six 22-lb. fragmentation bombs can be carried in the wings for short-range attacks.

Aerodynamically the Heinkel fighter is as near perfect as any airplane yet built, but is not easy to fly and not popular for night flying. In the latest models a false fairing of light-alloy sheet has been put behind the pilot's head running aft to the fin above the main outline of the fuselage, being wrapped over conically and riveted to the main structure. Design, construction, characteristics, and performance are described and a cutaway drawing showing location of equipment is included.

There are rumors of new Heinkel, Messerschmitt, and Focke-Wulf fighters, each with a new Daimler-Benz 24-cylinder X engine of 2275 hp. *Aeroplane* November 16, 1939, pages 600–601, 3 illus.

A Secret Weapon. Of all the machines in service in, or being delivered to, the German Air Force, the greatest secrecy attaches to the Junkers Ju.88 high-speed twin-engine bomber. Nose of the machine appears to be arranged like that of the Dornier Do.215, accommodating the crew, and gun positions seem to be located above and below the fuselage. Auxiliary fins are said to be located at the tips of the tailplane, but this has not been confirmed.

A description of the Ju.88 is quoted from the October 12th issue of the magazine, and "reconstruction" drawings of the airplane in flight and of the tailplane design possibly used are presented. *Flight*, November 23, 1939, page 416, 2 illus.

Great Britain

Britain's Military Aircraft. Description of the design, construction, and in some cases armament, equipment, characteristics and performance of British military aircraft. *Flight*, November 30, 1939, pages 435–440, 440a–440h, 441–444, 45 illus., 3 illus. on pages 453–454.

Britain's Civil Aircraft. Short descriptions of civil aircraft produced by the Armstrong-Whitworth, Chilton, Chrislea, Cunliffe-Owen (Mark I and II types) Dart, DeHavilland, General Aircraft, Marendaz, Mayo, Mosscraft, Percival, Short, Taylorcraft, and Wicko companies. *Flight*, November 30, 1939, pages 445–448, 11 illus.

Slit-Slots on the Chilton. Slots fitted on the Chilton single-seater light monoplane are rather more elaborate than any previously seen in England, and slightly different from the cut-through type fitted to the Lockheed 14 and the Tipsy. They are actually more like those used by Col. Clark in America on the Clark F-46 Duralmold airplane. All three parts, the main wing, the slat, and the circumscribed shape, are of airfoil section. As fitted, slots cover 29 percent of the wing span and 67 percent of span of the ailerons. Construction is entirely of wood, no bolt or metal being used. In straight stall with flaps closed, no amount of wing dropping can be induced except by use of a large amount of rudder. Design of the slots, performance of the slotted Chilton airplane, advantages of fixed slots, decrease of top speed due to the Lockheed and Clark slots are described. These slots are illustrated. *Aeroplane*, November 23, 1939, page 642, 5 illus. *Flight*, November 23, 1939, page 421, 2 illus.

The New Marendaz Trainer. New two-seater low-wing monoplane trainer described is in production and has been designed for preparing the pupil on a type of machine which will represent a step toward the larger and more powerful types which he will be called upon to fly later. Designer has aimed at retaining in its features and characteristics the virtues of the biplane trainer by careful choice of wing section, c.p., and c.g. positions. Airplane has built-in leading-edge slots near the wing tips, an unusual type of undercarriage in which the wheels roll sideways in landing, and a tail skid so mounted that bottom of the fuselage can be covered to prevent dirt from accumulating inside. Any inline engine of from 80 to 150 hp. can be installed. Length 22 ft. 4 in. Wing span 34 ft. Range at cruising speed of about 95 m.p.h., 350 miles. *Flight*, November 23, 1939, pages 418–419, 5 illus.

U.S.A.

An Aeroplane for Survey Work. J. H. Warner. Long detailed description of the Abrams pusher-type airplane with twin-fin tail and tricycle undercarriage. *Aircraft Engineering*, November, 1939, pages 415–416, 3 illus., 1 table.

Lockheed "Lodestar." New Model "18" Lockheed transport weighs 17,500 lb. and will cruise non-stop the distance of 1150 miles at a speed of 220 m.p.h. Ceiling is 24,600 ft., landing speed 65 m.p.h., and estimated top speed 236 m.p.h. Lodestar will carry 14 passengers and a crew of three. Two Pratt and Whitney 850-hp. engines. Wing span 65 ft. 6 in. Short description. *Aviation*, November, 1939, page 42, 2 illus. *Aero Digest*, December, 1939, page 49, 2 illus.

Martin Model 167W General Purpose Bomber. New Martin Model 167W three-place general-purpose twin-engine low-wing bomber is designed for fast mass production output and is now available for export. Pilot and bombardier's stations are located forward in close proximity to each other to facilitate effective communication and cooperation. Gunner is stationed aft of the trailing edge of the wing where there is a partly retractable turret enclosure in the top of the fuselage for a 0.30 cal. flexible gun firing up and aft, and another similar gun can be mounted in the bottom of the fuselage to fire through a hatchway with removable covers. Wing span 61 ft. 4 in. Useful load (increased range) 6365 lb. and (maximum range) 6807 lb. Pratt and Whitney Twin Wasp R-1830 series engines. Speed and climb are given for three types of engine, that with the Model SC3-G engines giving a maximum speed of 274 m.p.h. at sea level, 304 m.p.h. at 11,500 ft., and rate of climb at sea level 2000 ft./min. Design, construction, armament, characteristics, and performances are described in detail. *Aero Digest*, December, 1939, pages 71, 74, 4 illus.

Timm Ready to Fly Plastic Trainer. Designed to meet Army requirements, the PT-160-K two-place tandem low-wing monoplane is powered by a Kinner R5 Series 2 160-hp. engine. Manufacturer claims a top speed of 137 m.p.h., cruising speed of 127 m.p.h., and landing speed of 46 m.p.h. Process of construction followed by Timm calls for a triple criss-cross laminated spruce plywood heavily impregnated with phenol formaldehyde. Sheets are formed to desired shapes by dies and presses heated for the operation. Short description of design and construction. *Aero Digest*, December, 1939, pages 77–78. *U.S. Air Services*, December, 1939, page 37, 1 illus.

U.S.S.R.

Types of the Red Air Fleet. For a number of years aircraft design in Russia tended to stagnate, whereas in the last few years very noticeable progress has been made. Soviet designers appear to have concentrated on maneuvrability as being of greater importance than performance. Greatest advance has been made in the design of single-seater fighters.

Fighter prototypes known to be in the course of development include: a cantilever biplane (on the same principle as the Darmstadt two-seater of 1931) fitted with the M-85 (Gnôme-Rhône K-14) engine, and supposed to have a top speed in excess of 310 m.p.h. and to be exceptionally maneuverable; DI-6 two-seater biplane fighter (also used for ground attack work) developed by Policarpov, which is similar to the I-15, is fitted with the M-25 engine, is armed with four fixed and two movable machine guns, and which has a maximum speed of 226 m.p.h. at 8200 ft., ceiling 31,800 ft., and range of 528 miles; and a newer machine having a maximum speed of 248 m.p.h. No further details are given of these prototypes.

Design, construction, armament, characteristics, and in some cases performance are discussed in detail for the following: I-15 single-seater biplane fighter (two types of cowling, 750-hp. M-25 radial engine, one type reaching a height of 47,800 ft. with an engine supercharged to 16,400 ft.) proved in China and Spain and inspired by the Curtiss Sparrow Hawk; the newer I-16 monoplane (M-25 engine) designed by Policarpov and resembling the Granville Gee Bee racers; I-P all-metal version of the I-16 fitted with a shell gun in each plane; Z.K.B.19 single-seater fighter (M-100 liquid-cooled engine derived from the Hispano-Suiza 12Ycrs, reputed speed 300 m.p.h.) exhibited at the 1936 Paris Salon; Z.K.B.26 medium bomber (two M-85 engines) thought to have been the machine flown 4000 miles by Kokinakki and landing in New Brunswick; original S.B. three-seater bomber (two M-25 engines, maximum speed 236/248 m.p.h., disposable load 3307 lb.); S.B.2 bomber (two M-100 engines, maximum speed 261 m.p.h., and bomb load to 1764 lb. with a radius of action of 621 miles); and T.B.6 bomber (four M-34 Russian-designed engine supplied with compressed air from one M-100 engine in the fuselage, loaded weight of 49,500 to 51,700 lb. with maximum speed of 280 m.p.h. at 26,240 ft., radius of action with 4410 lb. of bombs 1242 miles.

Mention is made of the Kallinin experimental tailless twin-engine bomber, L.R. two-seater observation biplane (900-hp. M-34 ungeared unsupercharged engine, maximum speed 193 m.p.h.), a two-seater dive-bomber monoplane specially developed for ground attack (M-85 engine, 8 machine guns), and Russian naval aircraft. Large Consolidated flying boat is believed to be in production. *Aircraft Engineering*, November, 1939, pages 411–414, 424, 16 illus.

Air Transportation

Trans-Atlantic Air Services. Major R. H. Mayo. Flights over the Atlantic in the past 20 years; alternative routes for air transport services; nature of services required; range and speed requirements to be met by transatlantic aircraft; assisted take-off (including the catapult and composite aircraft and refueling in flight); and stratosphere flying. Complete British Association paper. *Jour. Royal Aeronautical Soc.*, November, 1939, pages 884–908, 3 tables.

First issue—Characteristics of the possible intermediate positions on the North Atlantic routes, and the relationship of Eire to these routes; stages and total distances involved in the various alternative routes; outstanding advantages of providing sufficient range for direct crossing from Southampton to Montreal or New York; possibility of regular operations over the North Atlantic during the winter months; and nature of the services required.

Second issue—Requirements of aircraft in regard to performance; the design problem; and assisted take-off with catapult and composite aircraft. Continued. *Engineering*, November 10 and 17, 1939, pages 541–542 and 565–567, 3 tables.

Trans-Atlantic Air Services. Major R. H. Mayo. Refueling in flight, and stratosphere flying. Concluded. British Association paper. *Engineering*, November 24, 1939, page 594.

Connections Between France and Its African Empire. C. Rougeron. Airplanes used and airlines; transportation of mail, passengers and freight; and requirements of clientele. *L'Aéronautique*, September, 1939, pages 339–345, 4 illus.

Richard du Pont Explains His Air Feeder Program. All American Aviation, Inc., provides a daily direct air-mail and air-express service to 58 towns in Pennsylvania, West Virginia, Ohio, and Delaware. Schedule requires 75 pickups and the airplanes fly 1540 miles daily. Pickup load has been limited to 20 lb. but loads of more than 70 lb. have been picked up in tests. In making the pickup the plane passes over the masts at the station at from 50 to 70 ft. altitude. Cable is trailing the grapple about 10 to 25 ft. above the ground when it strikes the pickup rope between the masts and airplane flies at between 90 and 110 m.p.h. Service, pickup devices, airplanes used, and future plans are discussed. *U.S. Air Services*, December, 1939 pages 17–18, 1 illus.

Transport Flying in War-Time. Civil war paint, official mind, work done by the air-transport pilots of National Air Communications, and an account of flights from England to France and Holland. *Aeroplane*, November 23, 1939, pages 642A-643.

War-Time Communications. Foreign and British civil air-transport services operating in and out of Britain's main war-time civil air base in the South of England. Brief notes are also given on Scandinavian airlines operating since November 1, statistics of Swedish Air Lines up to September 1, changes in services of Scottish Airways, and the latest about K.L.M. *Aeroplane*, November 30, 1939, pages 674–677, 2 illus.

Balloons

"Lighter-Than-Air" in Switzerland. Account of the International Balloon Race at Zurich, May 14. *Airship*, July-September, 1939, page 18, 1 illus.

The Marek and Emmer Hot Air Balloon. Marek-Emmer II fire balloon (volume 2600 cu. meters, 17.25 meters diameter, 23 meters high) rose to 9374 meters on September 27, 1937, beating world records for spherical balloons of the 5th and 6th categories. Envelope is made up of forty spindles of fireproofed tissue of a resistance of 50 kg./sq.cm. Balloon is of the netless type and car is fixed to the envelope by 16 divided lengths around a carline, with bridges situated in the lower third of the envelope. Gasoline is worked through to the burner by an electrically-driven pump. Starting up from cold is assured by use of propane gas. Weight: envelope, casement, riggings, and accessories 300 kg.; heating apparatus 30 kg.; fuel 150 kg.; crew of four people plus freight 300 kg. Total weight 750 kg. Description of balloon, heating apparatus, inflation of balloon, mounting and landing. From L'Aérostier, May. *Airship*, July-September, 1939, pages 15–17, 2 illus.

Propellers

Fundamental Problems of Controllable Propeller Technique and Consideration of the Most Important German Designs. K. A. Schmidt. Fundamental problems of the controllable mechanism are discussed, and designs of controllable propellers produced by three leading German propeller manufacturers are described. Pending as well as future problems of propeller technique, such as the negative setting for braking purposes, are dealt with. Table gives data on the following propellers: Argus, Smith, Schwarz, Everel, deLavaud, Bendix, Hamilton, Rotol, Junkers V.S., V.D.M. (Pistolesi design), Curtiss, and Ratier. Operating part of the Argus and Junkers V.S. propellers are shown in two illustrations each and a cutaway drawing of the V.D.M. (Pistolesi) propeller is included. *Luftwissen*, October, 1939, 11 illus., 1 table.

Ratier Variable-Pitch Propellers. P. Leglise and H. Filloux. Automaticity in function of speed in propellers having electrical control and infinite number of pitch; various types of airplanes on which the different types of propellers are used; elementary realization of the variation of pitch, and direct manual control without automatism; propellers having interrupters in series and manual control; inconveniences of manual control; propellers with interrupters in series and automatic control and typical installation on single-seater pursuits; a unique control; assembly of the automatic control and its operation; and the phenomena of "pompage."

The following drawings are included: Ratier automatic control operating to decrease pitch; 1939 Ratier v.p. propeller with electrical control (cutaway drawing); diagram of electrical installation of the Ratier automatic control for variable-pitch propeller; manual operation of the control when increasing pitch; diagram of an ultra-simplified manual control; diagram of stabilization of r.p.m. by centrifugal regulator; diagram of installation and operation of signalling circuits in an electrical control of a Ratier variable-pitch propeller, and of a connection between two electric circuits of a Ratier installation; electric circuits of a variable-pitch propeller carrying two interrupters in series, one for large pitch and one for small, and a perfected manual control (installation in the more recent models of the Caudron Simoun airplane); and the electrical control of the variation of pitch of a propeller without an interrupter by means of a hard commutator. Controls for the Ratier variable-pitch propeller carrying an automatic installation are shown in photographs. *L'Aéronautique*, September, 1939, pages 349–364, 29 illus.

Improved Propeller De-Icer Spinners. Latest type of de-icer spinners manufactured by Aircraft Accessories uses rubber in shear and incorporates two sets of shock mounts on either side of the blades. Mounting results in a perfectly balanced assembly in which the spinner "floats" while seeking its proper position of rotation under any operating condition, and provides a flexible coupling between engine and spinner minimizing impact effect in engine speed changes. De-icing fluid induction and slinging means are built integrally with spinner. Spinners are available in 20- to 50-in. diameter and for two- or three-bladed Curtiss and Hamilton Standard propellers. Few details. *Aero Digest*, December, 1939, page 114, 1 illus.

Rockets

British Fly Rocket Plane. Successful flight of an air-jet propelled plane invented by F. Whittle, an ex-member of the Royal Air Force, was reported in an article in the "New York Times" of July 30. Part of the article describing the operation of the propulsion apparatus is quoted. Invention consists primarily of a centrifugal compressor, a turbine, and a combustion chamber with propelling nozzles through which gas is discharged to propel the airplane. Quantities of air are continuously drawn in, compressed, heated by combustion of oil fuel, and passed through nozzles to the buckets of a turbine. Expansion through the turbine is only sufficient for driving the compressor. Second expansion takes place through a nozzle in rear of the plane. Backward thrust of the airflow provides the propulsion force for the plane. Parts of U.S. patent No. 2,024,274 issued in 1932 to S. Campini of Milan, Italy, are also quoted. This patent covers a similar method of propulsion for aircraft. Drawing shows reaction propulsion method and plant. Short article. *Astronautics*, November, 1939, pages 9, 14, 1 illus.

New Model Stability Tests. A. Africano. Dry-fuel flight tests of model rockets at Mountainville, N.J., on September 10 are described. Models were constructed of light cardboard and balsa wood into which the "cartridge" part of the ordinary commercial skyrocket could be slipped to provide propulsion. Models, test procedure, altitude sighting instruments, timing the shots, weight of powder in cartridges, and effect of tail area are discussed. Summarized results of 23 rocket shots are presented in a table. *Astronautics*, November, 1939, pages 1, 3–6, 2 illus., 1 table.

Thermal Efficiency Overemphasis. J. Shesta. A more practical yardstick of rocket motor performance than that of thermal efficiency is suggested. One rational basis of comparison for rocket motors is provided by jet velocity attained, and a more convenient unit as a figure of merit would be thrust coefficient equal to jet velocity divided by G or 32. Theoretical jet velocity and thermal efficiency are calculated for two runs, and it is shown that while thermal efficiency is lower for one run than the other, jet velocity is higher. *Astronautics*, November, 1939, pages 7–8, 1 table.

Miscellaneous

Tethering the Airplane. W. C. Clayton. Method of "making fast" the airplane is discussed. *Aviation*, November, 1939, pages 30–31, 76, 78, 3 illus., 4 tables.

Aircraft Instruments and Navigation

Laying Out a "Time Sight." T. P. Conlon. Particular astronomical triangle that must be solved for a time sight can be accurately diagrammed to a scale by the application of a simple mechanical projection. Method used is similar to that previously described for the layout of the Great Circle Track. Method of calculation is explained and solution of the problem of chronometer error is discussed. *Aero Digest*. December, 1939, pages 67–68, 4 illus., equations.

Armament

Fields of Fire. Side- and top-view drawings illustrating blind areas and vulnerable spots of some German two-engine bombers. *Aeroplane*, November 23, 1939, page 633, 8 illus.

Electrical Equipment

Electric Motors for Auxiliary Power. A motor for undercarriage operation, designed by Croydon Engineering Company in cooperation with a British aircraft manufacturer, has an output of 4 hp. at 4500 r.p.m. with adequate reserve of power. A system of clutches provides for immediate disconnection of motor and application of a brake on the operation of the trip switch. A motor developing 1.7 hp. at 4000 r.p.m. for flap operation and similar duties is being manufactured. It is adaptable also for use on bomb hoists, the rating being slightly less, and the design is modified to embody a changeover switch for direction of rotation and choice of speed. The A/20 motor (weight 7 lb. and output 6 hp.) has already been used for operation of bomb doors and retractable tail chassis operation. Few details only and photographs. *Aeroplane*, November 30, 1939, page 671, 3 illus.

British Standards Specifications. Safety glass for land transport, and electric incandescent lamps for aircraft (landing lamps and other than landing lamps). Brief abstracts of these specifications. *Aircraft Engineering*, November, 1939, page 430.

Fire Prevention Equipment

Metal Fires and Their Extinction. Compounds are discussed (DX Standard, DX Special and DY paste) which have recently been developed to simplify the problem of dealing with aluminum, magnesium and other metal fires. Conditions governing ignition and requirements of extinguishing agents are also taken up. Formation of a cap is described. *Light Metals*, November, 1939, pages 365–366, 8 illus.

Miscellaneous Equipment

British Standards Institution. Hexagonal-headed bolts (low-tensile steel) and hexagonal steel nuts (Nos. 5 A.1 and A.16) for aircraft purposes; and comparisons of hardness numbers (B.S. No. 860). Short reviews of these British standard specifications. *Engineer*, November 17, 1939, page 503.

Flexible Bearings. Oscillith bushes, a French invention, are intended for use as flexible bearings for joints or fittings without lubrication, to be durable and silent, and to require no attention after installation. Bush consists of a cushion made of a casing of rubber in which is molded a spiral spring to bring the rubber into the necessary state of deformation. Brief description. *Aeroplane*, November 30, 1939, page 673.

Testing Apparatus

The National Physical Laboratory. Research undertaken in the Electricity Department. Dielectric properties of plastic materials; measurements of inductance; stability of magnets; electric cables, insulators, and circuit breakers; high-voltage surge phonomena; quartz ring oscillators; photometric standards; optical sensitivity; and artificial illumination. *Engineering*, November 24, 1939, pages 587–589, 2 illus.

Metals

Fatigue Problems in Structural Designs. A. V. Karpov. Insofar as bridge trusses and, in particular modern welded bridges, are concerned, no satisfactory design can be made unless proper consideration is given to fatigue problems. Discussion covers: stress-resisting capacity as a fundamental property; perfect designs; engineering design; life of structures; refinements in design; fatigue properties of structural alloys; stress-resisting capacity of these alloys; and limited stress-resisting capacity. Drawings include: time-stress diagrams for building columns, bridge truss member and engine part, fatigue diagram (40° base line), and a developed fatigue diagram—time-stress representation. A table gives the stress-resisting capacity of alloys. *Metals & Alloys*, November, 1939, pages 346–352, 5 illus., 1 table.

Inside Surfaces Induction Hardened. Process of heat treating by electrical induction, used in the Budd Detroit plant, makes possible the heat treatment of the inside diameters of metal cylinders from 2 in. in diameter up and in lengths limited only by design of equipment. Outside diameter and all other unhardened areas can be machined after heat treatment of the inside diameter. Depth of hardened area is accurately controlled, and distortion is held at a minimum. Description. *Iron Age*, November 30, 1939, page 40, 1 illus.

New Developments in Automotive Materials. Stainless-steel "lumber," offered by Allegheny Ludlum Steel Corporation, consists of thin sheets (0.0095 in.) of Allegheny metal (18-8) permanently bonded to an inert mineral backing material to form strong rigid panels. Machinability of Bessemer steel has been improved by flame control. New high-strength silicon-brass die-casting alloy has been developed by A. U. Seybolt and B. W. Gonser. Col-alloy atomic welding paste and rod for atomic welding of nonferrous alloys, especially aluminum alloys, and the Colaweld method employed to weld both ferrous and nonferrous alloys. Estox Metaseal 494 rust preventative and protective coating for steel, brass and other metal products. Short descriptions. *Automotive Industries*, November 15, 1939, pages 526–527.

Corrosion and Protective Coatings

Bright Nickel Deposits. A. W. Hothersall and G. E. Gardam. Study of their structure and properties. Definition of terms; matt and bright nickel deposits; structure and smoothness of the basic metal; and microstructure of bright nickel deposits. Part of investigation carried out for British Non-Ferrous Metals Research Association. To be concluded. Electrodepositors' Technical Society paper. *Metal Industry*, November 24, 1939, pages 455–458, 6 illus., 1 table.

Protective Coatings for Magnesium. T. P. Hoar. Progress is being made in France with a galvanic method of coating magnesium without applied current (presumably an "internal electrolysis") which gives a coating similar to that produced by the chemical-dip method, but the authors of the report reviewed prefer to rely mainly on improved chemical-dip methods followed by painting or lacquering of various types. The four main protective processes recommended by the Société Générale du Magnesium for use in different circumstances and for different alloys are quoted.

Several new electrolytically formed coatings preferred by J. Frasch are described differentiated as those using an alkaline bath and those employing an acid bath. Results of corrosion tests obtained are given. Coatings described by J. Pomey, E. Fourquin and X. Hardy are all based on the well known sparingly soluble nature of magnesium fluoride, but a whole range of mixed basic fluorides has also to be considered. A coating with good mechanical as well as corrosion resistance was achieved by a preliminary treatment in cold potassium permanganate solution acidified with acetic acid, which gives a porous, but flexible, coating of oxides of manganese. The a.c. and d.c. electrolytic processes are then applied to the material, and a very good mechanically and corrosion-resistant coating is obtained. The threefold process and a simpler but more lengthy treatment worked out by the authors are described.

Favorable treatments arrived at in all these three researches have two general principles in common: formation of a durable, but porous, coating of insoluble chromium or manganese oxides; and the filling up of the pores. The Société Générale du Magnesium prefers paint or varnish, Frasch prefers silicates, and Pomey uses mixed basic fluorides. From Chimie et Industrie 1939, 41, 320C., 313C., and 298C. *Metallurgist Sup., Engineer*, October 27, 1939, pages 67–70, 4 tables.

Properties of Thin Metal Films. In the description given in the August issue of the properties of thin metal films (based on Riedel's review), an important feature was the almost complete non-conductivity of extremely thin films, and the failure of relatively thick films to approach the resistivity of the massive metal.

The large values of about 200 $m\mu$ for the mean free path of the electrons in the alkali metals (as found by Lovell and Appleyard) give satisfactory agreement between theory and experiment for alkali metal films, showing that Thomson's theory is adequate in respect to resistance of the films exceeding about 1 $m\mu$ in thickness. High resistance of the thinnest layers is put down to the probable formation of cracks resulting possibly from the effect of temperature at which the layer was deposited, so that all formulas which do not take this into account must fail in respect to the thinnest layers. Riedel believes alkali metals are especially suited for such investigations, and that satisfactory information regarding mean free path of electrons is obtainable for other metals, provided layers can be degassed. Perucca's hypothesis, some optical properties of films and structure of films are also discussed. Continued. *Metallurgist Sup., Engineer*, October 27, 1939, pages 65–67.

Metal Working

Modern Practice in Drilling, Boring, and Reaming. Theory and practice of tool forms evolved for working of aluminum and magnesium alloys. Reasons for modification of standard types are discussed. *Light Metals*, November, 1939, pages 381–384, 16 illus., 4 tables.

Tools for Deep-Drawing and Pressing. J. D. Jevons. Tool design insofar as it affects the hardening operation. First issue—Need for cooperation necessary between designers and hardeners; normalizing; stress relieving; rate of heating; time of soaking; hardening temperature; quenching; soft spots; temperature of quenching medium; manipulation; and tempering.

Second issue—Decarburization, and precautions to be adopted in order that it may be obviated or reduced to a minimum. Charcoal as a packing material; "bright" hardening; salt-bath furnaces; defects attributable to packing; general precautions; personal element; and need for care in using automatic control. Concluded. *Metal Industry*, November 17 and 24, 1939, pages 425–428 and 449–451, 2 illus.

Surface Finish. Developments in honing and superfinishing. Processes and machines are described. *Automobile Engineer*, November, 1939, pages 383–387, 7 illus.

Iron and Steel

Creep of Some Chromium-Molybdenum Steels. H. D. Newell. Effect on creep of increasing the molybdenum content of the familiar 4–6 percent chromium, 0.50 percent molybdenum steel, as shown by the cooperative investigation of the Allegheny Ludlum Steel Corporation, Babcock and Wilcox Tube Company, and Climax Molybdenum Company.

There does not appear to be any significant advantage for the higher molybdenum alloys as against the standard 0.50 percent molybdenum alloy throughout the temperature range studied, although the higher molybdenum alloys show values consistently toward the high side of the range of variation for the 0.50 percent molybdenum steel, except for the 0.01 percent rate at 1000°F. There is an indication of slightly better resistance to creep of the 1 percent and 1.5 percent molybdenum steels at 1100° and 1200°F., but there is not sufficient difference in stress values to justify the increased cost. *Metals & Alloys*, November, 1939, pages 342–345, 7 illus., 7 tables.

Austempering in Successful Commercial Operation. Recently developed process of heat treating steel to impart toughness and ductility along with relatively high hardness. Austempering as applied in the Worcester plant of the American Steel and Wire Company is described. Properties of 0.180-in. diameter steel rods, which were obtained by the ordinary quench and tempering method, are compared with those secured by austempering. Austempered hardness ceilings and suggested maximum austemperable sizes for various carbon and alloy steels are indicated in a table. *Heat Treating & Forging*, October, 1939, pages 499–503, 6 illus., 2 tables.

Non-Ferrous Alloys

The Deep-Drawing of Aluminium. A. G. C. Gwyer and P. C. Varley. Results obtained from a practical form of testing. Influence of variations in die clearance, blank-holder pressure, and punch and die radii, tests to determine deep drawing quality of a metal sample, and the authors' experiments on the deep-drawing quality of aluminum with redesigned tools are discussed. Using a new die the authors were able to draw more deeply than before and found that it was possible to detect differences in drawing quality by behavior of the metal in the first draw alone. For soft temper a hemispherical punch permits of greater reductions than a flat-ended one but for the work-hardened tempers the reverse is the case. By either warming the metal or the tools to about 100°C., the warming up process can be dispensed with and maximum reduction given immediately. Procedure, tools used, results and the formation of ears on drawn shells are described. Paper for Aluminium Congress in Zurich. *Metal Industry*, December 1, 1939, pages 465–469, 4 illus., 10 tables.

Light Alloys. K. Bungardt. Dynamic strength characteristics of light alloys at low temperatures. For both aluminum and magnesium alloys, fatigue strength under bending increases with decreases in temperature, especially in the case of Al-Cu-Mg alloys, Al-Mg alloy containing 4.68 percent Mg and Mg-Mn alloys 20 percent. Impact strength also increases by 15–20 percent with reduction in temperature from +20°C. to −65°C. except for an Al-Mg alloy containing 7 percent Mg, a Mg-Mn alloy containing 7 percent Al, and a Mg-Mn alloy containing 2 percent Mn. For these three alloys reduction of temperature has a very slight detrimental effect. Very brief abstract from Yearbook of German Aeronautical Research. *Automobile Engineer*, October, 1939, page 363.

A Note on Yttrium-Aluminum Alloys. W. Kroll. Increase in high-temperature strength, or hot-hardness, of aluminum piston alloys, could it be obtained without impairment of other properties, would be advantageous. From melting points obtained by Trombe, which are given, it would appear that yttrium might be of benefit.

High Cu and high Si aluminum alloys, representing two classes of simple piston alloys, were made up with and without about 8 percent Y. Hardness determinations with 7.95, 7.72, and 16.35 percent Y, and without Y are shown in a table. Structure of the 16.35 percent Y alloy, and hot-hardness of Y-Al alloys in comparison with ordinary Al and Y-free alloys are illustrated. While Y additions somewhat increased hardness and maintained a slightly higher level of hardness over the temperature range to 300°C., effect shown is not impressive. Methods of reducing Y into Al are mentioned. *Metals & Alloys*, November, 1939, pages 332–333, 2 illus., 1 table.

British Progress in Forging Aluminum Alloys. J. T. Robinson. Fundamental principles and procedure used for the working of wrought alloys in England are discussed. References are made to forging aircraft-engine parts and crystal structures are illustrated. Aluminum alloys, due to their resistance to deformation, are extremely severe on the steel forging dies, and many difficult problems have arisen and have had to be overcome as a result. Direction of grain flow in the manufacture of the steel die in relation to the sunken impression is also of the utmost importance. Best steel for forging dies has been found to be nickel-chrome-molybdenum steel, heat treated to give Brinell hardness of about 300. *Heat Treating & Forging*, October, 1939, pages 489–492, 504, 8 illus.

Magnesium Alloys in Aircraft. A. W. Winston. Survey of recent developments in the United States, including sand castings, design factors, wrought forms, fabrication methods, and protection. Table shows composition, typical mechanical properties, and uses of magnesium alloys. Reference is made to Army Air Corps and Navy aeronautical specifications. From Metal Progress. *Metal Industry*, November 10, 1939, pages 409–412, 2 tables.

Testing of Metals

The Dilagraph. E. D. Soderstrom. "Dilagraph," by means of which steel draws its own "picture" as it heats and cools, makes it possible to visualize the critical zones and leads to clarification and better understanding of the thermal equilibrium and heat treating diagrams. Apparatus comprises a balanced lever arm to which is attached a clamp to hold one end of the rod being tested, a screw actuated slide bar to which the board holding the paper is attached, a flexible balanced copper-cable link to the lower clamp, and an insulated top clamp with copper-cable connection. *Welding Jour.*, November, 1939, page 702, 4 illus.

Electron Diffraction and Surface Structure. High-temperature technique and investigations intimately concerned with the practical significance of oxide films on aluminum-alloy pistons. A specimen heater adopted for electron-diffraction investigations at high temperatures is described and illustrated. Adhesion of electrodeposited metals, importance of cathode condition, Beilby's fundamentally-sound conception, and oxide film on aluminum alloys are discussed. *Light Metals*, November, 1939, pages 371–374, 4 illus.

Magnetic Examination of Light Alloys. H. Auer. New method of following structural changes which lead to important modifications in the mechanical properties of light alloys. Magnetic susceptibility of pure aluminum falls steadily with rise of temperature. In the stable heterogeneous state magnetic susceptibility of the alloy is slightly lower than that of pure aluminum at all temperatures, but in the homogeneous solid-solution state it is very much lower and increases instead of falling with rise of temperature. Change from homogeneous to heterogeneous state during age hardening can be followed by magnetic susceptibility measurements. Susceptibility-temperature curves for pure aluminum and a 5 percent copper-aluminum alloy, and susceptibility-log-time curve for 5 percent copper-aluminum alloy during age hardening are illustrated. Phenomenon suggesting an initial "de-aging" process is described. Experiments carried out with initial aging at 100° showed this phenomenon is dependent on stage to which low-temperature aging has progressed and temperature to which it is heated subsequently. Brief. *Light Metals*, November, 1939, page 364, 2 illus.

Varied Applications of Thickness Gages for Thin Nonmagnetic Layers. M. A. Rusher. By far the greater number of applications have been either on flat surfaces or those having a large radius of curvature, requiring no special calibration and giving greatest accuracy obtainable. The thickness gage has been adapted to measuring the thickness of non-magnetic coatings on steel and iron, and even on less magnetic materials such as nickel or cobalt. Gage is described in detail and applications for measurement of coatings on a 3-ft. diameter pipe and welding rods some of only $^{3}/_{32}$-in. diameter are mentioned. Thickness of silver sheets over nickel and steel backings, of rubber vulcanized on steel, of non-magnetic metals sprayed on steel, and of various thicker platings where non-magnetic metals are used have been measured. *General Electric Rev.*, November, 1939, pages 486–487, 3 illus.

Yield Point Phenomena. Appearance of Lueders' lines and of the palier, or yield-point extension in the stress-strain curve, which occur at "yield" in tensile tests, and changes of structure are discussed. Results of experiments obtained by M. Kuroda on carbon steels and on nonferrous alloys, and the upper yield point found by J. G. Docherty and H. O'Neill are reviewed.

Pure irons or higher carbon steels failed to show marked yield phenomena. On the basis of this theory, when boundary structure is weakened by lack of carbon—as in pure irons—quenching, or grain growth, the characteristic Lueders' lines fail to appear. Increase in carbon content merely increases pearlite which inhibits deformation at yield. *Metallurgist Sup., Engineer*, October 27, 1939, pages 71–73, 1 illus.

Welding

Finned Tubing by Welding. D. James. Brown Fintube Company has developed a fast production method for applying fins longitudinally to tubing, the bond between fin and tube being made by means of resistance welding. Permanence and heat conduction of the integrally welded bond for the full length of fin contact with the tube are said to be superior to those obtained in fins and tubes joined by any of the mechanical methods. Examples of structural uses of finned tubing and description of the welding of the tubing. *Iron Age*, December 14, 1939, pages 46–47, 3 illus.

Properties of Light Metal Welds. P. Brenner. Corrosion resistance and other properties of welded aluminum alloys. Results of tests on Al-Mg-Si and Al-Cu-Mg alloys are described, and results of the whole investigation are summarized. Interesting data on the Al-Mg-Si alloy (Pantal), effect of re-aging after welding on corrosion resistance, corrosion resistance after welding, and results of microscopic examination are dealt with.

Highest corrosion resistance, both in the welded and unwelded condition, is shown by pure aluminum and by alloys of the Al-Mn (Mangal) and Al-Mg-Mn (KS-Seewasser). No noteworthy change in tensile properties could be established even after drastic corrosion tests extending over two years (stirring tests according to DIN.E.4853). KS-Seewasser possesses tensile strength more than 100 percent higher than that of pure aluminum. Al-Mg_7 alloy (BS-Seewasser) is approximately as corrosion resistant in the unwelded condition as the three materials mentioned, and suffers, in the welded condition, a considerable loss in tensile strength. Concluded. Aluminum Congress paper. *Metal Industry*, November 17, 1939, pages 429–433, 13 illus.

The Causes of Cracks in Welded Aircraft Steels. O. Werner. Cracking observed in gas welding of thin aircraft steel, plain-carbon or alloyed, is distinct from cracking observed in arc welding thick sections of low-alloy structural steel. Cracks in thin gas-welded steel sheets are visible in base metal at edge of weld at temperatures of about 700°C. For a given carbon content probability of cracking increases as sulfur content is increased. Phosphorus content appears to be of minor significance, if any. Probability of cracking decreases as temperature at which steel is refined in the melting furnace is raised.

Temperature of the AR_3 transformation had no effect on cracking nor was there any difference in tensile strength and ductility at elevated temperatures between steels which cracked and those which did not. It appears that cracking may be ascribed to relatively small amounts of FeO and MnO (approximately 0.01 percent oxygen) which react with acetylene to form water vapor, which, in turn, cracks the steel. A less pronounced effect of a similar nature is exerted by sulfur in steel which forms H_2S. Phenomena are similar to those exhibited in hydrogen embrittlement of copper.

Data given include: chemical composition and crack sensitivity of steels; total oxygen content of sensitive and insensitive steels; determination of oxygen combined as FeO and MnO in some of the specially refined basic open-hearth steels; composition of rods and sheets used by H. Cornelius; and results of Focke-Wulf rigid-clamp and unclamped welding tests on these materials. Contribution from the German National Materials Testing Laboratories, and discussions by W. Eilender, H. Pribyl, and H. Cornelius. Long abstract from "Archiv Eisenhuettenwes," March, 1939. *Welding Jour., Welding Res. Sup.*, November, 1939, pages 425–428, 5 tables.

Formation of Cracks after Welding. B. Bochenek. Some kinds of chrome-molybdenum steels widely employed in construction of airplanes, the chrome-manganese-silicon steels introduced comparatively recently, and even some carbon steels with a higher content than 0.2 percent carbon show minute cracks after oxyacetylene welding even when operation is carried out faultlessly. Results of German D.V.L. investigations are reviewed, and Focke-Wulf, Bollenrath, and Gatzek contrivances for welding clamped sheet-metal cuts are described and illustrated.

Discussion covers: causes for the occurrences of cracks after welding, and results obtained in German experiments by O. Werner and by Badenheuer; connection between crackability after welding and microstructure of the steel, which is not clear; influence of hydrogen content on behavior of steel after welding; effect of method of welding on formation of cracks, oxyacetylene giving the worst results, welding by arc in hydrogen (Arcatome) producing better results, and electric arc welding the best; selection of welding method for different cases; avoidance of the occurrence of cracks after welding to a considerable extent by suitable design of joints; and recommendations for joint design. Translated from the Polish "Technika Lotnica," July. *Aircraft Engineering*, November, 1939, pages 428–430, 15 illus., 2 tables.

Properties of Light Metal Welds. P. Brenner. Corrosion resistance and other properties of certain aluminum alloys after gas butt welding. Sheets 1.5-mm. thick of Reinaluminium 99.8, Mangal (Al-Mn), KS-Seewasser (Al-Mg-Mn), BS-Seewasser (Al-Mg_7), and the aluminum-copper-magnesium alloys, Pantal (19V), Bondur (17-65), Albondur (A17/65), and Bondurplat (P17/65) were tested.

Greatest resistance to corrosion was exhibited by pure aluminum, Mangal, and KS-Seewasser both in the welded and unwelded condition, while behavior of BS-Seewasser (Al-Mg_7) was rather different. Supplementary tempering of the homogenized material at 100°–200°C. was found to be very deleterious because the resulting finely distributed grain boundary precipitations are capable of leading to serious intercrystalline corrosion. To clarify certain points Al-Mg sheets containing about 7 percent Mg were welded in both homogeneous and heterogenous condition and comparative corrosion tests were then carried out. Micrographs of the two differently treated sheets are reproduced.

Experimental details, experimental results, and advantages of heterogenous structure are discussed. Condition and strength values after welding and different treatments are given in a table. To be continued. Paper for Second Aluminium Congress. *Metal Industry*, November 10, 1939, pages 405–408, 7 illus., 1 table.

Shrinkage and Other Initial Stresses in Welds. M. F. Sayre. Conditions under which crack failures occur, theory of crack formation, extent to which entrapped stresses are permanent, after-effect from entrapped stresses, and recommendations for future work are considered. The five basically different types of welding failures due to thermal effects are considered including: cracks which occur while the metal is still a red heat or white heat; cracks occurring apparently below the transformation temperature and within the so-called blue-brittle range or secondary brittleness range of the material; cracks connected with martensite formation; failures resulting from geometry of pieces being welded, or of weld itself; and failure occurring some time after the welding and resulting from the combination of live load stresses with entrapped stresses or from the entrapped stresses alone. Report of research at Union College. *Welding Jour., Welding Res. Sup.*, November, 1939, pages 393–397.

The Use and Application of Portable Spot Welding. C. E. Heitman. A complete "Shotweld" machine as used in the stainless-steel fabricating shops of Edward G. Budd Manufacturing Company consists of: an air or hydraulically operated welding tool; a welding transformer; a welding timer which serves to control as well as to time the flow of welding current; and a weld recorder for recording and indicating the consistency of welding current and time. Description of equipment and operations. *Welding Jour.*, November, 1939, pages 689–693, 5 illus.

Welding and Cutting of Stainless Clad Steel. W. B. Keelor. The Type 304 18-8, Type 347 columbium-bearing, and Type 317 molybdenum-bearing steels are covered in this explanation of welding and cutting procedures. Twenty percent represents the standard for cladding thickness. Welding process, joint design, and oxyacetylene cutting are discussed in detail. *Welding Jour.*, November, 1939, pages 723–725, 3 illus.

Plastics

Microscopy in the Resin Industry. T. G. Rochow. Application of micromethods, especially microscopic ones, in the study of typical resins for various commercial uses. Physical properties of 31 resins, microscopical characteristics of resins, and internal structure of molded resins are discussed. *Industrial and Engineering Chemistry, Anal. Ed.*, November 15 1939, pages 629–634, 20 illus., 1 table.

Materials Available. Short articles reviewing briefly the chemistry, general characteristics, developments during 1939, methods of fabrication, forms available, typical applications, and outstanding properties of various plastic materials. "Acrylic Resins," D. S. Frederick. "Alkyd Resins," A. G. Hovey. "Casein Plastics," "Cast Phenolic Resins," W. R. Thompson. "Cellulose Acetate," H. K. Haviland. "Cellulose Acetate Butyrate," C. H. Penning. "Cellulose Nitrate," J. M. DeBell. "Cold Molding Compounds," S. Pellerano. "Coloring Materials," W. H. Peacock and R. H. Kienle. "Ethylcellulose," D. R. Wiggam. "Fillers—Asbestos and Diatomaceous Silica," A. B. Cummins. "Fillers—Cotton Flock and Woodflour," V. E. Meharg. "Furfural-Phenol Resins," E. E. Novotny. "Lignin Plastic," R. M. Boehm. "New Plastic Materials Expanding the Field for Rubber," W. L. Semon. "Paracoumarone-Indene Resin," J. A. Kenney. "Phenolic Resins (Molding Type)," H. S. Spencer and A. F. Shepard. "Shellac," W. H. Gardner. "Styrene Resins," L. E. Humphrey. "Urea Resins," W. H. Machale. "Vinyl Acetal Resins," A. F. Randolph. "Vinyl Ester Resins," G. C. Miller.

A plastic properties chart, 1939–1940, gives property values based on maximum and minimum figures submitted by a number of manufacturers. Trade names of these plastics and their producers names and addresses are given in the Directory Section. *Modern Plastics*, October, 1939, pages 22–186, many illus., tables, equations, and 4-page chart on suppl. sheet.

Testing of Materials

Small Equipment for Mechanical Testing. Determination of hardness of various types of materials is considered together with the carrying out of bend tests on brittle alloys, punch-shear tests for sheet metal, and special tensile tests. Testing of fabrics as well as of metals and apparatus used are described. *Light Metals*, November, 1939, pages 378–380, 18 illus.

Meteorology

Improvement in Radio-Sounding Balloons: A Short Cycle Radiosonde. J. Piccard and H. Larsen. Every four seconds the new radiosonde described transmits information as to pressure temperature and relative humidity. The thermometer scale, from −60° to +40°C. is divided into 100 equal divisions of 1°C. each. Barometer scale is divided into 100 divisions corresponding to equal increments of height (850 ft. each up to 85,000 ft.). Scale of the hygrometer is divided into 50 equal divisions. Provided the thermometer and barometer themselves follow the changes of weather elements with sufficient accuracy, this means that maximum error of the thermometer is ± 0.5°C., and that maximum error of the barometer is 425 ft. Carrier wave is modulated and signals are given in ordinary Morse code easily received by ear or on a standard tape recorder without special equipment. *Rev. Scientific Instruments*, November, 1939, pages 352–355, 3 illus.

Static Emanating from Six Tropical Storms and Its Use in Locating the Position of the Disturbance. S. P. Sashoff and J. Weil. Technique of locating the apparent source of atmospherics by employing several stations located at a considerable distance from each other and equipped with cathode-ray-tube direction finders. Data obtained on six tropical storms are discussed, and results are compared with the estimate of the position of the storm center as reported on the daily bulletins of the United States Weather Bureau. Some evidence of the close connection between static and meteorological conditions is presented, and it is suggested that further studies be made along the same or similar lines to establish the feasibility of this method for locating the center of tropical storms by means of their associated static. *Proc. Inst. Radio Engrs.*, November, 1939, pages 696–700, 11 illus.

On the Origin of Tropical Air Near the Western American Mainlands. D. Blake. Question of whether exceptionally warm moist air masses which often enter the United States by way of the Western Central American and Mexican coasts do not have their source over the Gulf of Mexico or the tropical Atlantic Ocean and move across the Mexican Cordillera to the Pacific side. Various sources of information are quoted and the conclusion is drawn that during the season when hurricanes are most apt to form in the vicinity, strong winds are not prevalent in the passes, and therefore this cannot be the place, if there is any, where the TA air finds its way to the Pacific Ocean. *Am. Meteorological Soc., Bul.*, November, 1939, pages 385–389, 1 illus., 1 table.

On the Motion of Rotating Storms. O. J. Stewart. In order to visualize a possible mechanism of hurricane motion, and retain in the picture the two seemingly incompatible concepts of wave and vortex, the hypothesis is made that a revolving storm travels by adding to itself forward and discarding air and energy aft, this procedure at the same time allowing the center to remain calm. The Magnus effect is also considered. *Am. Meteorological Soc., Bul.*, November, 1939, pages 389–390.

New Mechanical Anemometer "Musella." F. Muscila. Portable field anemometer constructed by "La Filotecnica," of Milan, is specially suited for mobile stations where anemographs are not needed. Apparatus is a cup anemometer actuating a wind vane with mass balance. Wind speed is registered in r.p.m. on a dial, from which the actual speed is calculated by reference to a curve. Device is provided for returning the dial to zero. Scale of the goniometer, indicating wind direction, may be marked in 360°, in centesimal grades, or in points of the compass. Brief abstract. *Aircraft Engineering*, November, 1939, page 422. Complete article. *L'Aerotecnica*, May, 1939.

Air Forces

Effect of Air Power. T. P. Wright. The author's observations have shown him that the airplanes of Germany are well designed and well built, but that some of the performances of the pre-war planes were exaggerated. Planes of the Allies are equally good, surpassing those of Germany in some branches and probably inferior in others. The dominant role which air power has assumed in international affairs is pointed out, and reasons why Germany has not carried out her threat to bomb Britain and France are offered. *Aero Digest*, December, 1939, pages 57–58, 61, 3 illus.

Britain's Aircraft Industry. Introduction to "Britain's Military Aircraft," a survey of more than 30 different military aircraft types, the product of 18 aircraft-designing firms. In addition to these, although not mentioned, types are being manufactured which are not merely new as regards their detail composition, but which differ in class from any previously in service with the R.A.F. *Flight*, November 30, 1939, page 431.

Some More Mistakes of the Last War. C. G. Grey. Mistakes made in the previous war are pointed out with suggestions for avoiding them in the present war. Crimes of training; the twin-engine risk and cartwheel crashes; failure of one of two engines at take-off; waste of material in not using civilian-trained pilots, and waste of machines in not putting civil aircraft into use; the scandal of 1915, otherwise known as the Fokker Scourge, and the folly of continued production of obsolete aircraft; and the dangers of mass production. *Aeroplane*, November 23, 1939, pages 627–629, 1 illus.

Air Warfare

System for the Determination of the Course, Altitude and Horizontal Distance of an Aircraft from an Advanced Observation Post Using the Diagram of the Cotangents. A. J. Chinaglia. To assure greater success of anti-aircraft defense, it is logical to know the course of the enemy aircraft. Advanced observation posts signalling successive passage of the attacking airplanes have the advantage of permitting determination of the course without the necessity of making any assumptions provided that certainty exists of having detected in both instances the same craft. To prevent error, other methods were studied and the one described in this article requires only one observer, making successive observations either visual or acoustic. The determination is based on the assumption that speed, course and altitude remain the same and in addition the calculations require an estimate of either the speed or the altitude of the enemy airplanes. It is shown that the calculations are more accurate if the observer approximates the speed.

The original article gives the methods of observations and calculations and reproduces a number of charts and devices permitting simple and expeditious calculations of the course, altitude and horizontal distance of the observed aircraft. Brief abstract. *Aero Digest*, November, 1939, page 108. Complete article. *Rivista Aeronautica*, July, 1939.

Bearings

V.D.I. Recommendations for Bearings of Synthetic Resin Pressed Material. Recommendations for design and use of such bearings. Pressed materials and the methods of working them, design, installation, bearing loading, tube casting of bearing shells, and bearing journals are considered. *V.D.I.*, October 28, 1939, pages 1162–1163, 1 illus., 1 table.

Fuels and Lubricants

Fuel Technology and War. Col. W. A. Bristow. Processes and products already commercially established on a large scale in other countries, and work now being carried out on these lines which will inevitably, in the author's opinion, lead to new developments of the most remarkable character and offering new and immense possibilities to the coal industry. Other things being equal in rival air forces, the power of attack and defense will depend upon an unstinted supply of high-octane gasoline. Another revolution will be accomplished if the conversion of methane itself and its homologues into olefins can be carried out commercially. British Institute of Fuels paper. *Engineer*, November 10, 1939, pages 469–470.

Lubricants to Be Made from Fish Oil. The Japan Oil and Fat Company has decided to industrialize its process of manufacturing aircraft lubricants from fish oil. Besides whale oil, sardine and herring oils will serve as raw materials. Oil produced by the company's secret process is supposed to be superior in quality. Brief reference. *Industrial and Engineering Chemistry, News Ed.*, November 20, 1939, page 710.

Recent Developments in Diesel Lubricating Oils. G. L. Neely. Development, and service properties of a new compounded Diesel-engine lubricating oil including: anti-ring-sticking value; prevention of lacquer formation; reduction of carbonaceous deposits; noncorrosiveness to all types of bearing metals; and reduction of piston-ring and cylinder wear at both high and low temperatures. Although recommended specifically for Diesel engines, the oil also is suggested for gasoline engines particularly where engine deposits are troublesome.

Research program included a chemical investigation of fundamentals of lacquer formation and ring sticking, construction of a special research laboratory, design and operation of many special laboratory devices, preparation of hundreds of chemical compounds, full-scale engine tests in laboratory and field, and construction of a plant for manufacturing the compounding material selected.

Product is compared with straight mineral oils and corrosive-type Diesel lubricants. These laboratory tests required a total of 26 engines which included seven makes of Diesel engines and a few makes of gasoline engines. A fundamental property of lubricants is described which relates to the highest temperature at which an oil will wet a metal surface with a fluid film of sensible thickness. Engine-scuffing difficulties are prevented by lubricants having good spreading properties at high temperatures, and the new lubricant possesses superior spreading characteristics to which its breaking-in and surface-conditioning properties are attributed. Comparative economics of engine operation with this new type of lubricant and straight mineral oils are discussed. Application of the oil for cleansing or purging of both Diesel and gasoline engines is explained. Discussion by U. B. Bray on the effects of oils on octane requirement is included. *S.A.E. Jour.* (*Trans.*), November, 1939, pages 485–500, 37 illus., 5 tables.

Engine Design and Research

Cooling and Cowling of Radial Engines. L. Stipa. Transmission of heat from the cooling fins to the air which takes place by radiation and by forced convection, and the cowling of aircooled engines in such a way as to minimize head resistance while still maintaining an efficient cooling system are discussed. Head resistance may be minimized by having a secondary internal cowling with rounded edges, made in one piece with the front inner cowling. Diameter of the air inlet should be as large as practicable, the propeller should preserve its tapered profile close up to the hub, and the outer cowling should also be streamlined in section like a wing profile. A diagram in the original article shows details of this optimum form of cowling. Short abstract. *Aircraft Engineering*, November, 1939, page 422. Complete article. *L'Aerotecnica*, May, 1939.

Exhaust Efflux Propulsion. F. W. Lanchester. First issue—Fundamental principles in the use of exhaust efflux of aircraft engines as an auxiliary means of propulsion. Speed of flight should be of the same order or magnitude as the velocity of the gases, and the higher the better. The two distinct problems to be dealt with are characterized by two entirely different sets of conditions: namely, when exhaust release pressure is utilized to the full without involving back-pressure during the return or evacuation stroke, and when the efflux energy is wholly, or in part, due to the piston during the return stroke and in which there is consequent back pressure.

Taking the theory of the rocket, the author shows that, for the particular case of flight velocity equal to velocity of the mass ejected, the efficiency is 200 percent. The case of an airplane propelled by a force acting between it and a projectile traveling in the same direction and with the same velocity is considered.

Second issue—In order to minimize loss, the valve and guide and exhaust port should be, so far as possible, streamlined (internally) to lead smoothly into the exhaust pipe, so that velocity once imparted to the issuing gas is

not frittered away in eddy making or general turbulence. Ideal would be that the only material loss of energy shall be due to unavoidable skin friction.

It is shown by a case worked out for a flight velocity of 400 ft./sec. that with a 50-percent allowance for energy loss due to "wire drawing" at the exhaust valve and port, and skin friction in the discharge pipe, the gain is 6.3 percent to the horsepower delivered by the engine, and for 600-ft./sec. flight velocity a gain of 9.25 percent. For practical development, best solution appears to be the provision of a separate and individual exhaust pipe to each cylinder connecting with a port overrun by the piston at three-quarter stroke to allow for very clean flow. An inferior method is also described. Continued. *Flight*, November 16, 1939, pages 396a, 396d, 4 equations. *Flight, Aircraft Engr. Sup.*, November 23, 1939, pages 50 and 417, 1 illus., equations.

Gasoline Engine Combustion. H. Rabezzana, S. Kalmar, and A. Candelise. Method of analyzing engine combustion consists in treating separately the two simultaneous phenomena, burning and expanding of the reaction zone. Small volume increments burn at constant volume, then expand into both the previously burned and the still unburned portion of the mixture, until pressure equilibrium is reached. As reaction progresses, each increment burns under different conditions of pressure, temperature, and chamber volume. Time elapsed for a given linear flame displacement in space is determined by reaction velocity—the linear rate at which the flame travels with respect to the unburned gas.

After relations between flame velocity and reaction velocity have been derived, a method for predetermining pressure-time characteristics of a chamber design is presented. Pressure and flame records obtained in various types of combustion chambers and under various operating conditions are analyzed to show the effect upon the reaction velocity of such variables as mixture ratio and induction and compression turbulence, which in turn are controlled by engine speed, piston movement, chamber contour and spark advance. Throttle opening, temperature of unburned mixture, local hot spots in the chamber, such as exhaust valve, random turbulence induced by elements of chamber contour, and effect of chamber walls upon mass movement of unburned gases and consequent induced flame turbulence are also discussed.

Duration of entire combustion cycle, depending mainly on the reaction velocity is shown to control peak pressure and also detonation. For given fuel-air mixtures there is a definite relation between maximum pressure obtainable without detonation and corresponding time elapsed from ignition. Initial stage of combustion appears to be most sensitive to effects of various factors governing reaction velocity, and is the logical point of attack for future efforts in producing a more stable and faster burning mixture in the vicinity of the spark plug at instant of ignition.

This issue describes the experimental apparatus and procedure, process of combustion (combustion pressure, equilibrium pressure after expansion, location of flame front after expansion, shape of flame front, and effect of piston movement), application of the step-by-step method of analyzing the combustion process, flame velocity and reaction velocity and combustion zone and "effective" reaction velocity. *Automotive Industries*, November 15, 1939, pages 538–542, 17 illus., 2 tables, 8 equations. *Automobile Engineering*, October, 1939, pages 347–353, 17 illus., 2 tables, 8 equations.

Combustion. H. Rabezzana, S. Kalmar, and A. Candelise. Analysis of burning and expansion in the reaction zone. The variables controlling effective reaction velocity are discussed in detail, including mixture ratio, spark advance, engine speed, throttle opening, temperature of unburned mixture, local heating, local turbulence, and flame turbulence. Combustion time, power, and detonation are considered. Continued. *Automobile Engineer*, November, 1939, pages 377–381, 15 illus., 1 equation.

Interchangeability. Aerodynamic and structural problems encountered when planning a standardization of aircraft-engine units. Scheme is intended chiefly for multi-engine aircraft and, if satisfactorily developed, would not only greatly simplify the installation of aircraft engines, but would also permit an easy change from one engine to another. It aims at producing a complete installation which can be assembled as a unit and fitted to any particular class of aircraft without necessitating any modification of structure. The scheme could be divided into two groups, one applying to four or five different engines of similar horsepower, but it would be immaterial whether they were radial or inline engines. Other group would deal solely with engines of similar type, *e. g.*, inline engines.

Question of whether or not the fireproof bulkhead should be included in the nacelle, to be removed complete with engine mounting when change of engine is made, is considered. Coupling of connections, standardization of length and angular movement of engine controls so that they could be permanently connected to a standard control box positioned on the bulkhead, the question of accessibility, and cooling problems are discussed. *Flight*, November 16, 1939, pages 404–405, 1 illus.

Mixture Distribution and Volatility. L. A. Peletier, J. L. Tops, and W. J. B van Heeckeren. Distribution tests carried out at the Delft Laboratory (Royal Dutch Shell Group) are described. Seven fuels of different volatility were tested in a Wright Cyclone G.102 radial aircraft engine which had had 400 hours' service on the Amsterdam-Batavia route of K.L.M.

Relation between mixture distribution in the Wright Cyclone and fuel volatility was found to be much more complex than had been assumed. At low intake air temperature (about 15°C.) distribution became more uniform as fuel became less volatile, this result applying to both lean and rich mixtures. At high intake air temperature (about 50°C.) and at lean mixture, distribution became less uniform as fuel became less volatile up to a 90-percent point of 152°C. Regularity of distribution improved again with fuel having a 90-percent point of 185°C. which even showed the most uniform distribution of fuels tested. At rich mixture, distribution appeared to be practically independent of fuel volatility. Practically no difference in the unevenness of distribution was observed when the Chandler-Groves carburetor was replaced by a Stromberg carburetor.

Ideal distribution appeared to be obtainable when complete immediate evaporation takes place in the carburetor and impeller is being fed with a homogeneous vapor-air mixture; and when no evaporation takes place between carburetor and impeller, the latter serving as distributing agent for the liquid. Deflection of the mixture between carburetor and impeller is the main cause of distribution irregularities when neither of the ideal cases obtain. *Aircraft Engineering*, November, 1939, pages 407–410, 13 illus., 2 tables.

Poppet Valves and Operating Mechanisms. Main characteristics of the poppet valve in its many applications; way in which poppet valves are arranged in different cylinder heads; the types of valve used and advantages of particular arrangements; the mechanisms of poppet-valve operation; and further opportunities for the development of the poppet valve and of the methods of using it.

Advantages and disadvantages of four-valve and two-valve heads and influence of head shape and fuels are considered. Inertia, heat flow, and valve operation are discussed. Drawings illustrate: the layout of the Porsche-designed 600-hp. Auto Union racing-car engine which is considered a good design (16 cylinders set at a 45° angle, and narrow vee permitting the use of a single camshaft to operate the inclined valves); another method (Lancia) of operating inclined valves on a narrow vee engine with a single camshaft; and valve mechanism employed on the Napier Halford Dagger engine including a hydraulic tappet giving zero clearance. *Aeroplane*, November 16, 1939, pages 606–609, 13 illus.

A Review of the Relative Merits of Petrol Injection and Carburettors for Aero Engines. J. E. Ellor and F. M. Owner. Research of the U.S. Army Air Corps on fuel injection, begun in 1925, is mentioned in the historical review introducing the article. "The results obtained from these tests seem to have been satisfactory and a considerable amount of flying was done." It was even stated that the Air Corps planned to acquire, after July, 1935, only engines fitted with fuel injection. The reason why this prophecy was not fulfilled has never been stated publicly, but at that time the most difficult part of the system had not been tackled: namely, the controlling of fuel supply in flight.

Research results obtained by M.I.T. and the N.A.C.A., and by English, French, German and Italian research organizations are also reviewed. Drawings show: carburetion system of the Rolls-Royce Merlin, and diagrammatic operation of the Claudel Hobson 85M.B. Master Control carburetor, as well as fuel-injection systems, among them the Marvel system. Authors are with the Rolls-Royce and Bristol companies, respectively, and engines of these companies are referred to.

Discussion covers: function of modern carburetors; descriptions of the Rolls-Royce S.U. Merlin and Claudel Hobson A.V.T. 85M.B. Master Control carburetors; calibration of carburetor characteristics; weaknesses of the modern carburetor system; continuous injection; advantages of timed injection; manifold injection; combustion-chamber injection; and control systems. *Jour. Royal Aeronautical Soc.*, November, 1939, pages 838–862 and (disc.) 862–874, 18 illus., 1 table.

Some New Investigations on Old Combustion Engine Problems. G. Eichelberg. Heat flow in cylinder walls and pistons. Measured heat-transfer rates; heat transmission from the piston to the liner; heat conductivity of cylinder materials; and calculation of the temperature field. Continued. *Engineering*, November 17, 1939, pages 547–550, 22 illus., 1 table, many equations.

Connecting-Rod Bearings. W. Hampp. While load distribution in a roller bearing can be calculated on the supposition of complete rigidity and absence of clearance, in practice distribution differs appreciably from this supposition depending on how the load is transmitted to the bearing (deformation due to elasticity of the rod). A few rollers only may take the load, or deformation of the outer ring may cause a more or less uniform distribution of the load over a large number of rollers. Experiment showed that roller pressures were from 25–45 percent greater than in the theoretical case. In the distribution of the load over a large number of rollers, localities theoretically unloaded experience high pressures without effectively contributing to load capacity of the bearing. Each single roller is loaded over a relatively long path, reducing life and inducing skidding and tilting of the roller. Attempt should be made to equalize load distribution under tension and compression as much as possible and forces should be introduced tangentially by the rod so that roller pressure at right angles to the load is kept as small as possible. Brief abstract from Yearbook of German Aeronautical Research. *Automobile Engineer*, October, 1939, page 354.

Detonation. K. Zinner. "Rest gas," considered responsible for the phenomenon of engine detonation receives heat by adiabatic compression and transfer from the flame front. Most important source of heat energy resides in the "rest gas" itself and is associated with preliminary reactions of the chain type. Shape of combustion chamber and especially plug position will affect the amount of "activation" of the unburnt charge. If the flame path is long, available time for activation of the residue increases and with it the chance of detonation, unless care be taken to thoroughly cool all pockets. An increase in combustion speed reduces time of activation, but increases heat transfer to the residue brought about by compression. Reduction in activation time is more important and therefore a turbulent combustion chamber is antiknock. Brief abstract from recent issue of A.T.Z. *Automobile Engineer*, October, 1939, page 353.

Modern Aircraft Engines and Their Operating Characteristics. E. Vohrer. Survey of present status of development. The interlinking of numerous factors which separately and combined have an effect on the operating properties and characteristics of aircraft engines, makes more difficult the attempt to obtain a uniform basis for an unobjectionable quality comparison of engines of different origin.

First issue—Structural forms, cylinder capacity, cylinder number and output characteristics (output per liter and cylinder capacity, output per liter as a function of take-off power, and output per liter and engine r.p.m. at take-off); r.p.m. at different cylinder sizes; mean piston speed as function of cylinder capacity; frequency curves of bore-stroke ratio; effect of r.p.m. on b.m.e.p.; b.m.e.p. (take-off power) at different cylinder sizes; output load of pistons at different cylinder sizes; piston area as a measure of cylinder output; mean piston speed and output load; and change of effective propeller thrust with altitude (r.p.m. and supercharger pressure constant).

Second issue—Engine weight and external dimensions of the engine are considered.

Cylinder output increases in the case of cylinders of over 1.5 liters to 40 hp./liter, and cylinders below 1 liter cylinder capacity attain 58 hp./liter. The strongest engines do not have the highest liter output as a result of limitations caused by low r.p.m. High cylinder capacity utilization is possible only by high r.p.m. with simultaneous reduction of cylinder dimensions. Peak values of piston speed are at 16 meters/sec., most frequently 12 to 14 meters/sec., and stroke/bore ratios between 1.09 and 1.13 are used. Maximum mean pressure is 14.3 kg./cm.; those of 12 to 13 kg./cm.^{2} are used in supercharged engines; in passing from 87 to 100 octane number these values are increased 30 percent. For the power loading of the pistons values between 0.35 to 0.68 hp./cm.^{2} piston area are obtainable. The power increase in altitude engines (supercharge pressure and r.p.m. constant) moves between 3 and 4.75 percent/km. flight altitude.

Power weights below 0.5 kg./hp. were not available with one exception (Bristol Pegasus XXIII engine). When in liquid-cooled engines the radiator weight is considered, the cylinder capacity weights varied between 14 and 28 kg./liter. In the case of liquid-cooled power plants, it has been found possible to use a nacelle cross-section of 1750 hp./square meter. *Luftwissen*, September and October, 1939, pages 255–262 and 274–277, 18 illus., 2 tables.

One Hundred Horsepower—100 Lbs.—$100? W. B. Stout. The problem of designing a 100-hp. aircraft engine weighing 100 lb. and costing $100 for the small private-owner's airplane. It is said that future engines must be located within the wings. The six-cylinder flat opposed type of engine and geared propeller shaft so that the engine can be run up to a more economical piston speed are advocated. *Aero Digest*, December, 1939, pages 38–39, 5 illus.

Piston Ring Flutter. C. G. Williams and H. A. Young. Two theories as to the origin of flutter of piston rings are stated, and a third is discussed in detail. During the entire compression stroke the piston ring is normally in contact with the bottom face of its groove, being forced by rising gas

pressure acting on the upper side of the ring, while ring is forced outward by gas pressure behind the ring. Latter induces frictional drag between ring and cylinder bore which helps to keep the ring on the lower face of the groove. At sufficiently high engine speed it is suggested that the piston ring moves at t.d.c. from the lower to the upper side of the ring groove which severs communication between the back of the ring and combustion chamber, whereupon gas pressure behind the ring is relieved through the lower side clearance. Abstract Institution Automobile Engineers paper. *Automobile Engineer*, October, 1939, page 366.

Some New Investigations on Old Combustion Engine Problems. G. Eichelberg. Investigations of temperature effects. Calculation of temperature stresses and deformations is explained and some results of temperature stresses and deformations are considered. Results of a study of exhaust-valve temperatures are presented. Influence of cooling exhaust valves through the seat and through the valve stem is discussed. *Engineering*, December 1, 1939, pages 603–605, 22 illus., 2 tables, equations.

Valve Spring Breakage. R. Hunlich and W. Pungel. Most valve-spring breakages seem to be associated with surface defects (longitudinal grooves) produced during manufacture of the wire and aggravated by corrosion. On deep etching, the broken wire often showed in addition peculiar notches of sharply defined saw-tooth pattern. Notches are produced by fatigue when operating over a certain section of the Wohler curve, and formation is apparently independent of structure of the steel. Test results obtained on the 231 valve springs, of which 136 broke, are described in the original article. Of total breakages, only 23 showed no visible surface defects and, of 95 sound springs, 79 showed no surface defects. Brief abstract from Yearbook of German Aeronautical Research. *Automobile Engineer*, October, 1939, page 363.

Engine, Fuel and Lubricant Testing

Construction of Manometers for Measuring Flow. A. D. Loring. Direct-reading flow manometer gage described is built on the U-tube principle, one arm being a reservoir with a large horizontal cross-section, and the other a small-bore glass tube. The gage with an inclined scale, manometer for measuring cooling-water flow, and U-tubes for measuring performance of four fans operating in parallel are illustrated and described. *Industrial and Engineering Chemistry, Anal. Ed.*, November 15, 1939, pages 626–628, 5 illus.

Pressure Regulator for Dynamic Gaseous Systems. J. H. Bruun, Sun Oil Co. In many cases where gaseous reactions are studied by the dynamic method, it is desirable to maintain pressures higher than atmospheric in the reaction chamber. The new pressure regulator developed consists essentially only of a glass capillary tube and a brass rod (platinum or glass for reaction products containing corrosive gases). By means of a micrometer screw wire may be inserted to any desired extent into the glass capillary, thus increasing frictional resistance which controls the pressure in the reaction chamber or system. Short description. *Industrial and Engineering Chemistry, Anal. Ed.*, November 15, 1939, page 628, 1 illus.

Oil Film 0.0000001 Inch Thick Tested as Lubricant. A machine has been invented by W. Claypoole of Columbia University for testing lubricating properties of an oil film of this thickness. Machine is said also to reduce errors in measuring thickness. A special technique developed to obtain films of oil of only one two-hundred thousandths of the thickness of a silk fiber is briefly outlined. By measuring friction caused by rubbing diamonds and sapphires over highly polished and thinly lubricated surfaces of steel, gold, platinum, and rhodium, University engineers hope to discover some unknown properties of lubricants. *Industrial and Engineering Chemistry, News Ed.*, November 20, 1939, page 711.

Engines

Fifty to One Hundred Horsepower Five-Cylinder Angle Engine. New experimental engine now being flown has been developed by Glenn D. Angle for the light airplane field. Engine has a displacement of 184 cu. in., bore of 4.125 in., stroke of 2.75 in., outside diameter of less than 30 in., and weight of about 160 lb. The available power range extends from 50 to 100 hp. depending on operating speed. The engine has been developed to turn as high as 4000 r.p.m., 100 hp. being developed at 3800 r.p.m. Description. *Aero Digest*, December, 1939, page 61, 1 illus.

Germany's Aero-Engines. Cult of the inverted vee, "general-purpose" radials, and the Junkers Diesels. Daimler-Benz D.B.601 direct-injection 12-cylinder inverted-vee engine is essentially similar to the D.B.600, the latest model shown at the Brussels Show being the D.B.601-Aa. Maximum power is 1150 hp. at 2400 r.p.m., but for use in the record-breaking Messerschmitt which attained 469.225 m.p.h., it was boosted to give 1800 hp. at 3500 r.p.m. A large X-shaped Daimler-Benz engine of about 2000 hp. has been reported, which is assumed to be a developed combination of two D.B.600 engines. Contrary to rumors, this engine was not installed in the Heinkel and Messerschmitt record breakers.

The Junkers Jumo 211 inverted-vee engine is of slightly larger capacity (35 liters) than the D.B.600. A two-speed supercharger is incorporated and engine has been rated on 100-octane fuel. Modified for direct gasoline injection, and at present in production, it is known as Type Ba or Da. A set of twelve injection pumps is fitted between cylinder banks. Output of 1200 hp., quoted for the latest Jumo 211, is undoubtedly a take-off rating.

A few details only are given for the D.B.601 and Jumo 211, but other German engines are described more in detail, including: D.B.600 inverted-vee; Junkers Jumo 205 heavy-oil engine; B.M.W.132-Dc 9-cylinder radial engines (1691-cu. in. displacement), and latest of the series, the 132K developed for direct gasoline injection and giving a maximum output of 1000 hp.; and the Bramo Fafnir 323 9-cylinder radials (capacity 26.82 liters, 950 hp. for take-off, 670 hp. at 6730 ft. for cruising for the medium supercharger type, and 665 hp. at 13,750 ft. for cruising for the fully supercharged type).

Standardization of power units worked out by Junkers and applied to the B.M.W.132 radials, and cowlings for liquid-cooled engines are described. Illustrations include: the nose-type radial characterizing the installation of the Jumo 211 in the latest Junkers bombers; a sectioned Jumo 211; two-speed supercharger of a Jumo 210 showing automatic boost control; D.B.600 showing unusual mounting of the centrifugal supercharger; the cowled D.B.600 on the Messerschmitt Me.109 fighter; the cowled B.M.W. VI Prestone-cooled upright vee-12 and D.B.601 fitted in Dorniers; the cowled Jumo 211 in the Ju.88 bomber; the cowled D.B.601 in the Heinkel He.112U the cowled Jumo 205 Diesel in the Ju.86; and the cowled B.M.W. 132-Dc radial in the Arado Ar 95. *Flight*, November 16, 1939, pages 391–396, 15 illus.

Results of a Second Series of Tests in Order to Stabilize the Variation of Output of Engines with Temperature and Pressure. Results of tests carried out with a Fiat A.30 R.A.-bis aircraft engine in the Isotta-Fraschini plant under high-altitude conditions. The A.30 is a high-compression engine (compression ratio 1:8) with reduction gear but without supercharger and develops 600 hp. at 2600 r.p.m. on the ground, with reduced throttle opening, and 550 hp. at 2750 r p m. at 3000 meters at full throttle. Fuel used was A.S.3 (55 percent Stanavo, 22 percent benzene, and 23 percent alcohol—84-octane number). Lubrication was castor oil. Experiments were made to determine separately the effects of temperature and pressure on engine power.

In the original article the tests and results are described, and different formulas of correction necessary according to whether pressure is higher at intake than at exhaust, or *vice versa*, are derived. A correction formula for supercharged engines under test on the ground is developed to allow for increase of power at altitude due to diminished pressure at the exhaust.

The Fiat A.30 R.A.-bis was less affected by pressure inequalities than the Asso 750 previously tested, the correction being 1 percent for each 41 mm. in the former case, and 1 percent for 21 mm. in the latter. Coefficient c of the equation $\beta + 1 + \frac{1}{100} \cdot \frac{\Delta p}{c}$ varies mainly with height. In tests with the exhaust pressure less than the intake, the same formula is valid, but in this case the denominator depends mainly upon the intake pressure. Tests were all carried out with unsupercharged liquid-cooled vee engines. Further tests are now being made with the supercharged Asso XI R.C. 40 engine. Official report of the Construction Department of the Italian Air Ministry. Long abstract. *Aircraft Engineering*, November, 1939, page 422. Complete article. *L'Aerotecnica*, May, 1939.

Parts and Accessories

All-Metal Laminated Gaskets. Diagrams illustrating how an even thickness of the Dickson gasket is ensured around combustion-chamber openings, stud holes, and waterways. Brief reference only. *Flight*, November 16, 1939, page 408, 3 illus.

A Positive-Locking Panel Fastener. Typical application of the Oddie positive-locking fastener for engine cowlings is illustrated in a drawing. Fastener comprises a screw-headed stud of cadmium-coated mild steel, which is recessed to engage with a simple but effective clip incorporated in the mounting bracket. A resilient washer between bracket and panel absorbs vibration. Fastener can easily be locked or unlocked with a small coin. Few details. *Aeroplane*, November 16, 1939, page 618, 1 illus.

Detection of Loose Metal in Aircraft Lubricating Systems. One arrangement of the device consists of a grating of metal rods set in the pipeline, alternate rods being connected with one pole of the electric generator and, via a warning light, with the opposite pole. Warning light is set in the cockpit of the airplane. Any metal fragments too large to pass through the grating complete the circuit and switch the light on, but fine metallic particles produced in normal engine operation are passed without warning. In an alternative arrangement a special plug performs the same function as the grating. Device was invented by M. Van Os of the Royal Dutch Air Lines. Brief reference only. *Engineer*, December 1, 1939, page 543.

Prevention of Carburetor Icing and Other Suggestions for Flying Light Airplanes in Cold Weather. R. D. Hicks. Rules which should be followed during winter flying to prevent carburetor icing are given with an explanation of mechanism of carburetor icing and a description and diagram of the Continental carburetor air heater valve setup. *Aero Digest*, December, 1939, pages 44, 133, 1 illus.

Aircraft Radio

40-Cm. Waves for Aviation. Tests at M.I.T. have indicated that a practical apparatus has been developed for generating a 40-cm. "hillside" of signal for blind landing of airplanes. Horn radiators and a receiver having 15-microvolt sensitivity indicate the practicability of 700-mc. communication. Solution of the problem of instrument landing was proposed by I. Metcalf and was developed in the electrical engineering department of M.I.T. Apparatus was recently demonstrated in experimental form to C.A.A. officials at East Boston airport.

Description covers: beams from horn radiators; the 700-mc. generators; the 15-microvolt microwave receiver; and observations made during test flights. *Electronics*, November, 1939, pages 12–15, 9 illus.

C.A.A. Radio Developments for 1940. H. W. Roberts. Growing radio needs, current developments, and the prediction of future developments are discussed. *Aero Digest*, December, 1939, pages 40–41, 74, 4 illus.

Radio for Private Aircraft—Communications—Maintenance. H. T. Sagert. Itinerant aircraft radio troubles, and maintenance of radio equipment are considered, and the services and overhaul shop of Air Radio and Instrument Company are described. *Aero Digest*, December, 1939, pages 42–43, 4 illus.

Radio in Navigation. C. D. Tuska. The historical, technical, and practical development of automatic radio bearing indicators and radio beacons, and the practical application of radio in navigation are described. Concluded. Long bibliography. *Journal Franklin Inst.*, November, 1939, pages 581–603, 7 illus.

Italian Radio Beacons. Italian system of radio beacons for aerial navigation consists of stations grouped in threes and transmitting signals over medium wave lengths which are picked up by radiogoniometers installed in the airplanes and which help navigating officers to fix their position on their maps. Stations in a group transmit signals at the same frequency so that they can be picked up in succession. Every four minutes each radio beacon transmits a signal lasting two minutes and during the four-minute interval the other two beacons of the same group transmit their signals in succession. Brief reference only. *Aeroplane*, November 16, 1939, page 615

Aeronautical Personnel

Dealing with the Problem of Personnel. C. S. Mattoon. Supply of qualified men from an educational point of view will soon exceed the demand. The situation will then become one in which more of the better assignments, as well as some of those considered average, will be filled by men who were more interested in gaining valuable experience than they were in immediate remuneration. Selection of engineering personnel is discussed. *Aero Digest*, December, 1939, pages 36–37, 3 illus.

Model Tests on High Altitude Effects. H. Strughold. Chemistry involved in the burning of a candle is used as a model for the changes or alternations of the oxidative processes in the human being due to the reduction of partial pressure of oxygen at high altitudes. Alterations in volume of the candle flame due to mechanical effects caused by decrease of barometric pressure are discussed. Experiments were made in burning the candle at high altitudes in pure oxygen instead of air. When a cabin is flooded with oxygen at high altitude, there will be an increase in volume of the flame, especially of the oxidizing portions of the flame, which may increase the fire hazard in the plane in places where there is a combination of increase of oxygen at partial pressure and decrease of barometric pressure. *Luftwissen*, October, 1939, pages 278–279, 2 illus.